30 YEAR OPERATION AND MAINTENANCE PLAN

SAMPLING AND ANALYSIS PLAN
PART I - FIELD SAMPLING PLAN

ASBESTOS DUMP SUPERFUND SITE
OPERABLE UNIT NO. 1
MILLINGTON, NEW JERSEY

Submitted to:

New Jersey Department of Environmental Protection
Division of Hazardous Site Mitigation
Hazardous Waste Programs
Trenton, New Jersey

United States Environmental Protection Agency
Region II
New Jersey Remediation Branch
New York, New York

U. S. Army Corps of Engineers
New York District
Environmental Residency Northern New Jersey Area
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Revision 1

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Revision 0

January, 2001

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Executive Summary

This document presents the *30-Year Operation and Maintenance Plan (OMP), Sampling and Analysis Plan (SAP), Asbestos Dump OU-1 Superfund Site, Millington, New Jersey.* This document has been prepared for the U.S. Environmental Protection Agency (USEPA) Region II. This SAP provides the overall guidance for meeting the Data Quality Objectives outlined in the Sampling Scope of Work (Section 3.3.1) to be conducted at OU-1.

This SAP has been prepared in accordance with the USACE, Technical Guidance Document EM-200-1-3, *Requirements for the Preparation of Sampling and Analysis Plans.* The plan is divided into two parts, the Field Sampling Plan (Part I) and the Quality Assurance Project Plan (Part II). The Field Sampling Plan provides descriptions of procedures and protocols to be followed during field activities conducted at OU-1. The Quality Assurance Project Plan (QAPP) describes the quality assurance and quality control procedures to be followed for laboratory analyses of samples collected during field activities.

The remedial action was performed to prevent further migration of asbestos from the site. In conjunction with the NJDEP, the USEPA is committed to providing continuous long-term operation and maintenance for OU-1 to monitor groundwater, surface water, and sediments located within site boundaries and the surrounding area.

The objective of this SAP is to provide comprehensible, defensible, and accurate data that represents conditions at OU-1. This data combined with results from physical site inspections and resultant periodic maintenance will serve to verify that the remedy is functioning as designed and is protective of human health and the environment.

Distribution of the OMP, SAP, and QAPP is in accordance with the distribution listing provided in the OMP. Any revisions or subsequent modifications to these plans must be distributed in accordance with the distribution list.

Part I - Field Sampling Plan

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List of Acronyms

AHA	Activity Hazard Analysis
C	Celsius
CDM	Camp Dresser McGee
CIH	Certified Industrial Hygienist
COC	chain-of-custody
CQCM	Contractor Quality Control Manager
DOT	U.S. Department of Transportation
DQO	data quality objective
EA	Endangerment Assessment
FADL	field activity daily log
FSP	field sampling plan
FWV	Field Work Variance
GW	groundwater
IDW	investigation derived waste
IT	IT Corporation
mg/L	milligram(s) per liter
MS/MSD	Matrix Spike/ Matrix Spike Duplicate
NCR	Nonconformance Report
NEPA	National Environmental Policy Act
NJDEP	New Jersey Department of Environmental Protection
OMP	Operation and Maintenance Plan
OSHA	U.S. Occupational Safety and Health Administration
OU-1	operable unit number one
OU-2	operable unit number two
OU-3	operable unit number three
PCB	polychlorinated biphenyls
pH	*Potenz* Hydrogen
PM	project manager
PMA	phenylmercuric acetate
POC	point-of-contact
PQCM	Program Quality Control Manager
PQO	project quality objective
PPE	personal protective equipment

List of Acronyms *(Continued)*

PTFE	polytetrafluroethylene
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QCP	quality control plan
QCR	quality control report
QCSM	Quality Control System Manager
QAPP	quality assurance project plan
RA	Remedial action
RCRA	Resource Conservation Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
SAP	sampling and analysis plan
SD	sediment
SOP	standard operating procedure
SSHO	site safety and health officer
SSHP	Site safety and health plan
SVOC	Semi-volatile Organic Compound
SW	Surface Water
TCLP	Toxicity Characteristic Leaching Procedure
TIFA	
USEPA	United States Environmental Protection Agency
VOA	Volatile Organic Analysis

I. Field Sampling Plan

This part of the *Sampling and Analysis Plan, Asbestos Dump Superfund Site, Operable Unit No. 1, Millington, New Jersey* (SAP) presents the Field Sampling Plan (FSP). Here and after the site shall be referred to as OU-1. The SAP provides descriptions of the procedures and protocols to be followed during field sampling activities at OU-1. The details of specific field activities (e.g., proposed sampling locations, frequencies, and rationale for the locations and frequencies) are presented in Section 3.4, Scope of Work. This site-specific SAP contains applicable procedures and protocols that meet the site-specific Data Quality Objectives (DQOs). The second part of this SAP consists of the Quality Assurance Project Plan (QAPP), which describes the quality assurance (QA) and quality control (QC) procedures to be followed for laboratory analyses of samples collected over the post operational lifetime.

1.0 Project Description

1.1 Site Description

Operable Unit 1 (OU-1) is an 11-acre commercial property located at 50A Division Avenue in Millington, Morris County, New Jersey. Asbestos fibers, siding, and tile were disposed on a 5-acre area of the property. Figure 1-1 provides a site layout drawing.

OU-1 is bounded on the west by the Passaic River; on the north by the New Jersey Transit Authority, the Millington Train Station; and on the east and south by commercial businesses and private residences, respectively.

1.2 Site History

Asbestos, LTD. manufactured asbestos products at the Millington Site from 1927 to 1946. From 1946 to 1953, the plant was owned by Bernard E. Smith and operated under the name Smith Asbestos, Inc. (Smith), a manufacturer of asbestos roofing material and siding. During its tenure, Smith constructed dams on site to impound water from the manufacturing process. This allowed asbestos fibers that were in the wastewater to settle to the bottom. Periodically, asbestos sediments from the wastewater settling ponds was removed, disposed of on-site, and covered with soil. In May 1953, National Gypsum acquired the property and manufactured cement asbestos siding and roofing sheets at the plant until 1975. During National Gypsum's period if ownership, most of the waste generated from the production processes was recaptured and recycled.

Waste that was not recycled included broken siding and asbestos fibers. These waste products were disposed of on a 5-acre portion of the property during this time. This included a 330-foot by 75-foot area where predominantly asbestos fibers were disposed. After the limited space for on-site dumping reached full capacity, additional wastes were transported off-site for disposal.

From 1953 to 1972, National Gypsum utilized phenylmercuric acetate (PMA) as a fungicide coating on the asbestos shingles. Wastes generated from cleaning of the coating equipment were disposed of on-site in small pits located west of the manufacturing plant.

In May 1975, National Gypsum closed the Millington plant. In 1978, ownership of the land was transferred to TIFA. TIFA has since subdivided the property into several small parcels, which have been leased to other manufacturing and service companies.

Remedial investigations (RI) activities were previously conducted at OU-1 by McLaren Hart Environmental Engineering Corporation (McLaren/Hart) in order to evaluate soil, groundwater, surface water, and air media at OU-1. In addition, McLaren/Hart investigated and evaluated the stability of the asbestos material that was disposed at OU-1. The RI activities were conducted from August 1986 through November 1987 in accordance with work plans approved by the USEPA. Additional air quality and geotechnical investigations were conducted in March and May 1988, respectively. Based on the RI results, an Endangerment Assessment (EA) was conducted to identify potential risks associated with exposure to the site conditions.

Asbestos was the primary contaminant detected at OU-1. Asbestos was found in the form of broken asbestos tile, siding and fibers. The quantity of waste on-site was estimated at 90,000 cubic yards. Soil borings and historical information revealed that the "upland" portion of OU-1 contained broken asbestos tiles and siding, while the asbestos mound contained primarily asbestos fibers. The "upland" and asbestos mound portions of OU-1 were over lain with soil cover with depths varying from two inches to over four feet. Additionally, exposed areas of asbestos fibers were observed on the slope of the asbestos mound adjacent to the Passaic River. Heavy vegetation with thick underbrush and deciduous trees were observed.

Results of the RI sampling activities are summarized in Tables 1-1, 1-2, and 1-3. Figure 1-2 graphically represents previous and proposed sampling locations.

Prior to Remedial Actions (RA) taken at OU-1, some erosion of the cover material on the asbestos mound was noticed and documented by Camp-Dresser McGee Federal Programs Corporation (CDM) in the revised Sampling and Analysis Plan submitted to the USEPA on February 12, 1996.

In this document, CDM indicates that this occurrence, erosion of the previous cover material, had raised some concerns about the potential for long-term surface and stream erosion of the asbestos mound and migration of asbestos to the Passaic River. Since that time, IT has performed the remedial actions to limit the potential migration of asbestos material from OU-1 into the adjacent

waterways. The measures taken by IT in implementing this RA were an effort to diminish the potential impact this site could pose on the public health and the surrounding environment.

1.3 Recommended Remedy

The remedial action (RA) initiated for OU-1 included the following actions:

- The installation of a two-foot soil cover on the areas of exposed or minimally covered asbestos
- Construction of slope protection/stabilization measures along the asbestos mound embankments
- Surface run-off diversion channels.

In addition to these corrective actions: long-term monitoring, off-site monitoring; access restrictions; institutional controls to restrict groundwater use and limit development in the area; and the performance of treatability studies to evaluate technologies that may permanently remediate asbestos have been initiated.

Table 1-5 lists the type of contaminants previously identified above the detection limits at OU-1 and the Target Monitoring Guidelines anticipated for OU-1.

2.0 Project Organization and Responsibilities

The primary contractor will be responsible for conducting the monitoring program at OU-1. This work order will be managed from the NJDEP, located in Trenton, New Jersey. Figure 2-1 provides the general project organization complete with lines of authority within the project and program organization. Figure 2-1 lists the NJDEP/USEPA and the chosen contractor, which have responsibility for collecting samples and/or obtaining analytical data for the project.

2.1 New Jersey Department of Environmental Protection/U.S. Environmental Protection Agency

The USEPA maintained responsibility for the environmental investigation and remedial activities at OU-1 during the first year of operation. After such time the USEPA relinquished responsibility of operation and maintenance of the site to the NJDEP for the remaining monitoring period. The USEPA and NJDEP will assign project managers (PM) and point-of-contacts (POCs) who are responsible for directing all activities.

2.2 Contractor

The lead contractor is responsible for overall project management and will coordinate and direct the efforts of project team members. The roles and responsibilities of the contractor's program and project members are described in the following subsections.

2.2.1 Project Manager

The PM has direct responsibility for implementing all work plans and coordinating all field activities, data management, and report preparation. The PM will also provide the overall management of all project tasks and serve as technical lead and point of contact with the NJDEP POCs. The PM is also responsible for ensuring proper technical performance of all field sampling activities, and adhering to required sample custody and other related QA/QC field procedures to meet project objectives. Additionally, he is responsible for the coordination of field personnel activities, management of investigation derived wastes, checking of all field documentation, and preparation of Field Work Variances (FWVs), if required.

2.2.2 Contractor Quality Control Manager

The Program Quality Control Manager (PQCM), is responsible for implementation of project QA/QC in accordance with the requirements of this site-specific SAP, the site-specific Quality Control Plan (QCP), and other work plan documentation. The PQCM, in coordination with the

Project Chemist, will be responsible for participating in the field activity readiness reviews and inspections and the completion of Quality Control Summary Reports (QCRs). He is also responsible for approving variances during field activities before work continues; approving, evaluating, and documenting the disposition of Nonconformance Reports (NCRs); overseeing and approving any required project training; and developing audit/surveillance plans.

Site quality control activities will be managed by the Quality Control Systems Manager (QCSM). The QCSM will be responsible to implement the Quality Control program for all site activities, including, but not limited to:

- Implementation of three phase inspection program, if required
- Supervision of all site sampling activities
- Oversight of contract chemical laboratory
- Management of contract transmittals, central files and submittals
- Daily inspections for quality of work and compliance with regulatory requirements.

The QCSM has a direct reporting line to the PQCM, and has the authority to stop work at any time for quality related deficiencies observed during the contract performance period.

2.2.3 Project Chemist

The Project Chemist is responsible for the implementation and documentation of all project QA/QC protocols during field activities which are presented in this SAP. In this capacity, the Project Chemist will direct and implement the various components of the QAPP, as identified in the NJDEP, *Field Sampling Procedures Manual.* Additional exerts from this manual have been incorporated in this document to develop this overall comprehensive approach. The duties will include, but not limited to, ensuring chemical analysis and reporting performed by the subcontract analytical laboratories is in accordance with requirements defined in the QAPP and resolving questions the laboratory may have regarding QAPP requirements and deliverables. He/she has the responsibility for oversight of field sampling and analytical activities and documentation of field QC activities. He/she also has the responsibility for the coordination of data reduction, validation, and documentation activities related to sample data package deliverables received from the laboratories. The Project Chemist reports directly to the CQSM but will inform the PM of all information and decisions reported.

2.2.4 Site Safety and Health Officer

The Site Safety and Health Officer (SSHO) will conduct inspections to determine if operations are being conducted in accordance with Occupational Safety and Health Administration (OSHA), New Jersey Department of Environmental Protection regulations and the Site Safety and Health Plan (SSHP). The SSHO work with site supervision during execution of project activities, but reports directly to the certified industrial hygienist (CIH) with functional issues. An open dialogue is to be kept between the SSHO and project supervisory personnel in order to quickly address safety issues and implement corrective actions. The SSHO has the authority to suspend operations at the site due to the ineffectiveness of or non-conformance to this SSHP.

2.2.5 Contract Field Personnel

Contract field personnel are responsible for implementing all field activities in accordance with this SAP. A lead field technician will be responsible for ensuring

- Proper technical performance of the OMP and SAP,
- Adherence to required sample custody and other related QA/QC field procedures,
- Coordination of field personnel activities,
- Management of investigation derived wastes,
- Checks of all field documentation, and preparation of FWVs, if required.

The lead field technician reports directly to the PM, except in regard to QA/QC matters which are reported directly to the QCSM.

The lead field technician is also responsible for obtaining the required sample containers from the chosen analytical laboratory and for coordination of sample shipment to the appropriate analytical laboratory.

3.0 Scope and Objectives

This chapter presents the scope of work and specific objectives of the sampling efforts planned for the Asbestos Dump OU-1 Site. This chapter will provide pertinent information regarding the objectives of this SAP. The SAP defines the appropriate sampling procedures necessary to achieve the following Project Quality Objective (PQO):

> Confirm by laboratory analysis that the remedial actions taken at OU-1 have negated the potential migration of asbestos and asbestos fibers into the surrounding media.

3.1 Operable Unit Number 1

The USEPA established three operable units at the site; OU-1, OU-2 and OU-3. OU-1 consists of an 11-acre piece of commercial property on the eastern banks of the Passaic River. The western portion of the property lies within the 100-year floodplain of the Passaic River, which serves as a public water supply source for approximately 74,000 people. The USEPA's September 1988 Record of Decision (ROD) described the remedial approach designed for OU-1. The selected remedial approach included the excavation of asbestos contaminated material, installation of a 2-foot cap, installation of a retaining wall system, and construction of surface water runoff controls. These designs were implemented to achieve the overall remedial objective, encapsulation of asbestos and asbestos fibers. The underlying objective of this approach was to develop a system, which was protective of public health and the environment by negating the migration of asbestos and other contaminants and minimizing discharge of contaminants into surrounding media.

In order to meet the remedial objective for OU-1, the following RA controls have been implemented:

- Affected areas were re-graded and runoff controls were constructed to provide enhanced erosion control.
- A ten-foot retaining wall was constructed on the western portion of the site to stabilize the existing slope from further deterioration and potential migration.

- A two-foot soil cap was placed over the affected areas to provide protection from wind erosion and potential public exposure.

In addition to these physical controls, institutional control has been opted for he site to prevent future public exposure. The institutional controls include:

- Restriction of groundwater usage on the site
- Restriction of development on the site
- Development of an Operation and Maintenance Plan, which includes long-term monitoring.

The long-term monitoring program includes the collection of post-remedial samples to verify that the RA has achieved its overall objective, preventing the migration of asbestos material from the site. The tenure of the monitoring program, as required by the NJDEP, is 30 years. This SAP has been developed to encompass this time frame. Samples will be collected from groundwater, surface water and sediment locations and submitted for asbestos analysis. The respective monitoring guidelines can be found in Table 1-5.

3.2 Scope of Work

The work to be accomplished under this monitoring program includes, but is not limited to, the collection and analysis of groundwater, surface water, and sediment samples, and field report documentation. All work will be performed in accordance with applicable Federal, State, and Local regulations.

3.3 Project Objectives

The ultimate objective for this monitoring program is to provide the NJDEP and the USEPA, safe, responsible and cost-effective monitoring services to verify that the RA objectives initiated for OU-1 have met the overall objectives for the site, to prevent the migration of asbestos material. Each phase of the monitoring program presents specific objectives for verifying the RA's design performance. This SAP communicates the PQOs and DQOs essential to achieve regulatory acceptance of the remedial actions implemented at OU-1. The SAP presents the PQOs, DQOs, site-specific procedures to achieve the PQOs and DQOs, and the applicable technical and regulatory guidance necessary to ensure that the overall project objectives have been achieved.

3.4 Sampling Scope of Work

The sampling and analysis scope of work for OU-1 is best defined as the collection of groundwater, surface water, and sediment samples from the on-site monitoring wells, and previous sampling locations along the Passaic River, respectively.

In order to improve the efficiency of the monitoring program, minimize schedule delays and excessive costs associated with repeat sampling of the above mentioned media, the contractor should implement a rigorous inspection program during each successive field event. The inspection program suggested for OU-1 follows the USACE, Contractor Quality Management for Contractors, and will include the following inspection phases; preparatory, initial, and follow-up inspections. These inspections will provide the contractor with a check and balance system prior to, during and after field mobilization.

The sampling program has been developed to provide the public widespread sampling coverage through the use of frequent remedy verification sampling in groundwater, surface water, and sediment.

3.4.1 Collection of Groundwater, Surface Water, and Sediment Samples for Years 2 through 30

In an effort to provide consistency with pre-remedial, construction and post-remedial activities, the contractor should collect groundwater, surface water and sediment samples from the previously sampled locations at OU-1. Table 3-1 presents the proposed sampling locations for each media at OU-1.

In an effort to provide consistent and widespread environmental data, these monitoring points were chosen as being the most representative of the condition of the site and potential impact the site may have to the surrounding area. When reviewing the data gathered from each of the points a historical trend in asbestos concentrations can be referenced in the event of a future anomaly. These locations have been graphically represented in Figure 1-2 to provide the contractor with a visual depiction of the site coverage. Samples will be collected in the frequency identified in Table 3-3 and analyzed for asbestos by the appropriate method for the media of concern (groundwater, surface water, or sediment).

3.4.2 Analytical Requirements for Year 2

The proposed scope for sample collection includes the collection of samples from each media to be submitted for Asbestos Analysis. These samples will establish a baseline for the site and the surrounding area. Sampling will be conducted biannually during the second year of O&M and results will be evaluated to determine sampling frequency thereafter. Any site related contaminant found in groundwater, surface water, or sediment found to be above New Jersey or Federal Target Monitoring Guidelines shall be tested at a minimum sampling schedule of yearly. For a full listing of the sampling schedule and analytical procedures please refer to Tables 3-2 and 3-3, respectively.

3.4.3 Analytical Requirements For Years 2-30

During the remaining years of Operations and Maintenance the sampling frequency will be determined based on the results for initial year of sampling. This FSP will be revised according to the sampling frequency established. It is anticipated that sampling will take place on a schedule of every 5 or 10 years and the proposed analytical schedule for each media to be submitted for analysis includes the collection of samples from groundwater, surface water, and sediments for, at a minimum, asbestos analysis. Since the RA was constructed to mitigate the potential for asbestos to migrate to adjacent waterways, the interim time between the 5-year or 10-year marks should focus on determining if the RA is still functioning as designed. For a tabular representation of the proposed sampling schedule and analytical procedures for the subsequent and interim years please refer to Tables 3-2 and 3-3.

3.4.3.1 Groundwater Samples

The contractor is responsible for collecting, at a minimum, one grab sample from each monitoring well on-site. The locations to be sampled are listed in Table 3-1. Monitoring well, MW901, as shown on As-Built Contract Design Drawing C101 provided in the OMP Appendix C figure, has been identified in previous investigations (McLaren/Hart) as the site's background well. Based on previous analytical sampling events, it has been determined that the concentrations exhibited at this location are representative of the background water quality up-gradient of OU-1.

The contractor will collect, at a minimum, seven (7) post-remediation verification-record samples, 1 field blank, 1 rinsate blank, 1 trip blank, and 1 QC field duplicate sample. These samples will be collected from each of the seven monitoring wells during the initial year of post remediation monitoring biannual sampling. For the remaining years (Years 3-30), 7 record

samples will be collected from the 7 monitoring wells, 1field blank, 1 rinsate blank, 1 trip blank, and 1 Quality Control (QC) duplicate samples will be collected for each sampling event and submitted for asbestos analysis. After the first initial sampling year and subsequently at a 5-year or 10-year interval, it is anticipated that site data will go through a review process, modification to the existing scope and frequency may be implemented upon Agency approval

If any sample results exceed the Target Monitoring Guidelines for OU-1 see "Level Of Concern (LOC)" listed in table 1-5, additional samples may be collected from the subject well during the next sampling event and/or a sampling frequency established to monitor the location. Table 3-3 illustrates the number and type of samples to be collected from each sampling location.

3.4.3.2 Surface Water and Sediment Samples

The contractor is responsible for collecting, at a minimum, one grab sample from each surface water and sediment sampling location. The locations are listed in Table 3-1 and graphically depicted in Figures 1-1 and 1-2. Sampling location and SW/SD-5, will serve as upstream / background sample location for the site during each successive field-sampling event. Based on previous site investigations (McLaren/Hart) it has been assumed that the concentrations exhibited at this location are representative of potential up-stream and conditions. Sampling locations: SW/SD-1, SW/SD-2, SW/SD-3, and SW/SD-4 will be representative of potential site-related impacts to the Passaic River. Sediment and surface water sampling of the Passaic River will be performed starting at the most downstream location and moving upstream. Surface water will be collected before sediment.

The contractor will collect, at a minimum, 5 post-remediation verification-record samples for the analytes listed in Table 3-3, 1 field blank, 1 rinsate blank and 1 duplicate sample from the five previously mentioned sample locations for surface water and for sediments during the second year of post-remediation monitoring. For the subsequent sampling years (years 3-30), 5 record samples, 1 field blanks, 1 rinsate samples, and 1 QC duplicates samples will be collected from each media and submitted for asbestos analysis only for each sampling event. At year 5 or 10, it is anticipated that site data will go through a review process, modification to the existing scope and frequency may be implemented upon Agency approval. With this approval, it will be determined if a full analytical sweep be completed or only asbestos sampling be accomplished in the remaining years of post-remedial monitoring.

If any sample results exceed the Target Monitoring Guidelines for OU-1, additional samples may be collected from the subject location. Table 3-3 illustrates the number and type of samples to be collected from each sampling location.

4.0 Field Activities

This chapter presents the standard operating procedures (SOPs) associated with each of the field sampling activities anticipated for OU-1. The majority of field protocols and procedures presented in this document are based on previously approved plans for the site. These protocols and procedures provide guidelines as to how each activity should be performed. The text will identify SOPs that apply to a particular field activity, as well as the following details:

- Investigation objectives
- Field activity associated with the investigation
- Rationale for the selected field methods and details
- Numbers and volumes of samples to be collected
- Types and numbers of QA/QC samples
- Sampling apparatus.

Health and safety procedures associated with these activities are specified in the SSHP. Activity Hazard Analyses (AHAs) for each definable feature of work are included as an appendix in the SSHP. Individual SOPs are presented in Appendix A.

The following summary presents the sampling objective, the location and rationale, the apparatus, collection procedures, and sample preparation for groundwater, surface water and sediments post-remediation sampling. Subsequent chapters of this FSP present procedures for documentation, packaging and shipping, handling of investigation derived waste, and field instrument calibration.

Prior to sampling, procurement and preparation of sampling equipment per Tables 4-1, 4-3, and 4-5 as well as procurement and preparation of sample containers per Tables 4-2, 4-4, and 4-6 shall be confirmed. All sampling containers will be prepared in accordance with the OSWER Directive 9240,0-05A "Specification and Guidance for Contaminant-Free Sample Containers."

4.1 Groundwater

This section presents procedures for collecting groundwater samples to determine the chemical characteristics of groundwater during the post-remedial closure period and verify that the RA is functioning as designed. Groundwater samples will be collected from monitoring wells located on site.

4.1.1 Sampling Objectives

The sampling objective is to obtain accurate and defensible post-remedial verification samples of groundwater from the designated monitoring locations on-site (Table 3-1). This task will be performed in accordance with NJDEP/USEPA directives in order to verify that the Target Monitoring Guidelines have been maintained. The contractor will collect, at a minimum, one grab sample and perform asbestos analysis US EPA Method 100.2 for years 3, 10, 20, and 30. For the interim years, (Years 3-9, 11-19, and 21-29) only one sample for asbestos analysis will be collected from each point if NJDEP and USEPA determines that sampling is necessary.

4.1.2 Sampling Locations and Rationale

This section of the plan describes the sample locations and the rationale used to determine those locations for each post remediation sample collected during this monitoring program.

Monitoring Wells. The post-remediation verification samples will be collected from each of the seven on-site monitoring wells (MW901, MW902, MW903, MW904, MW905, MW906, and MW907). Monitoring well locations are presented on Figure 1-1. It is assumed that these seven wells will provide the most consistent data for pre-construction, construction, and post-construction activities. Monitoring well groundwater elevations are to be recorded on Table 1-0 at each sampling event.

In the event that a post-remediation verification sample fails to meet the monitoring criteria, the sample location may be re-sampled during the next sampling event upon Agency approval.

4.1.3 Sampling Collection Apparatus

All groundwater samples collected during this monitoring program will be collected using the USEPA Groundwater Sampling Procedure, Low Stress (Low Flow) Purging and Sampling (GW Sampling SOP Final March 16, 1998) procedures per Appendix C of the FSP. The procedures for collection of samples using these devices are outlined in the *EM200-1-3, Section C-2,* Requirements for the Preparation of a Sampling and Analysis Plan *(USACE, 1994),* and the Field Sampling Procedures Manual (NJDEP, 1992).

4.1.4 Sample Collection Procedure

Generally, the contractor will follow the procedures presented below in USEPA Groundwater Sampling Procedure requirements for the collection of groundwater samples using Low Stress

(Low Flow) Purging and Sampling. The groundwater sampling pump to be used must be adjustable rate, positive displacement ground water sampling pump (e.g. centrifugal or bladder pumps constructed of stainless steel or Teflon, a peristaltic pump may only be used for inorganic sample collection). The specific sample collection procedures for discreet grab samples are as follows (refer to Appendix C for full Sampling Procedures):

1. Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.

2. Check the well, lock, and cap and record observations.

3. Remove the well cap.

4. Note the elevation of the outer and inner well casings as provided in Figure 1-0 of the FSP.

5. Measure and record the depth to water (to 0.01 ft) in the well to be sampled prior to purging. Care should be taken to minimize disturbance in the water column, of any sediment that has accumulated at the bottom of the well, and of any particulate matter attached to the sides of the well.

6. Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be purged. The NJDEP requires that five well volumes of purge water be removed prior to sample collection.

7. Attach a section of decontaminated tubing to the portable sampling pump prior to lowering the pump into the well.

8. Slowly lower the pump, tubing, electrical line and safety cable until it contacts the water surface.

9. Set the pump depth to position the pump within the middle of the casing screen elevation. The pump intake must be kept at least two feet above the bottom of the well to prevent disturbance and resuspension of any sediment in the bottom of the well. Record the depth to which the pump is lowered.

10. Measure the water level again with the pump in the well before starting the pump. Leave the water level measuring device in the well

11. Start pumping the well at 200 to 500 milliliters per minute (ml/min). The water level should be monitored approximately every five minutes so that a steady flow rate is maintained that results in a stabilized water level with drawdown of 0.3 ft or less.

Pumping rates should be reduced to the minimum capabilities of the pump to ensure stabilization of the water level while maintaining pump suction to avoid entrainment of air in the tubing. Purge the well until pH, temperature, specific conductance, Eh, DO, and turbidity are each at equilibrium, and begin sampling. Equilibrium is established as follows: pH variation is less than 0.1 units, Temperature variation is less than 0.5 degrees Celsius (° C), conductivity is less than 3 percent variation in specific conductance, variance less the 10 mv for dedox potential, and less than 10% for DO and turbidity. Equilibrium will be established by three consecutive readings, where one casing volume is removed between each reading. The above measurements can be taken with a Horiba Model U-22 Multipurpose Probe, see Appendix D.

12. Once consistent equilibrium readings are obtained, do not remove the pump between purging and sampling.

13. Collect samples at a flow rate between 100 and 250 ml/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 ft.

14. Fill all sample containers with minimal turbulence by allowing the ground water to flow from the tubing gently down the inside of the sample container.

15. Preserve samples as necessary and verify that the pH is sufficient for the criteria.

16. Remove the pump and tubing after collection of the samples. The tubing, unless permanently installed, must be properly discarded or dedicated to the well for resampling by hanging the tubing inside the well.

17. Measure and record the water level and measure and record the well depth.

18. Verify that the polytetrafluroethylene (PTFE) or equivalent liner is present in the cap. Secure the cap tightly.

19. Label the sample bottle with an appropriate label with the appropriate sample identification as outlined in Section 5.0. Be sure to include all necessary information.

20. Place the filled sample containers on ice immediately along with the required trip blanks when analyzing for VOCs. When VOC analysis is not required trip blanks may not be included in the sample shipment.

21. Record the information in the field logbook, field sheet and complete all chain-of-custody documentation (see Section 5.0).

22. Secure and lock the well.

23. Decontaminate non-disposable sampling equipment including the pump, cable and wires after each well is sampled per decontamination procedures provided in this FSP and the Ground Water Sampling Procedure (Appendix C).

As field event dictate and as state-of-the-art becomes available, modifications to the sampling scope of work and the sampling procedures may be modified upon Agency approval.

4.1.5 Sample Preparation

The following procedure will be implemented for preparation of sample prior to shipment to the contract laboratory:

- Each sample jar will inspected to ensure that the sample identification number matches the sample collection log and sample chain of custody.
- Each sample jar will be individually wrapped to ensure the structural integrity of the jar for shipment to the laboratory
- The wrapped sample will be stored in a cooler provided by the laboratory and maintained at Cool 4 degrees Celsius (° C) for shipment to the laboratory.
- Decontaminate sampling equipment and shovel.

The collection of groundwater samples will be according to the above procedures. Standard Operating Procedure 3.1, located in Appendix A, discusses the Chain of Custody procedures, Sample Handling, Packaging and Shipping procedure, Sample Labeling procedures, Sampling Numbering procedures, Field QC Sampling procedures, On-Site Sample Storage procedures and Drum / Container Handling procedures for the sampling activity. The list of equipment needed for groundwater sampling is presented on Table 4-1 and a listing of the container requirements necessary to complete this task can be found in Table 4-2.

Field QA/QC samples, as described in SOP 18.1, Appendix A, may include field duplicate, split samples, and trip blanks. The duplicate and split samples will be collected from the same sampling point after the record sample is collected.

4.1.6 Sample Documentation

All groundwater sampling information for each sample will be recorded on a Sample Collection Field Sheet (Figure 4-1) including field instrument reading(s). The following information will be recorded in a field logbook and on a field activity daily log (FADL):

- Date/time of sampling
- Personnel present
- Sample location
- Sample number
- Analysis required
- Other data as required

Archived samples, if required, will be stored in on-site, samples-only, refrigerators at the field office for possible future analysis. The archived samples will be stored in accordance with SOP 19.1, located in Appendix A, at a maximum temperature of 4°C until shipped to a laboratory or disposed.

As part the archiving process, if required, control samples (field duplicates) will also be archived. Control samples will be submitted along with the archived samples asbestos analysis as specified in the site-specific SAPs.

4.2 Surface Water Sampling

This section presents procedures for collecting surface water samples at OU-1 to verify that the treatment was effective in encapsulating the contaminants of concern. Verification samples for this monitoring program will consist of grab samples collected from the sampling locations along the Passaic River identified in Table 3-1.

4.2.1 Sampling Objectives

The sampling objective is to obtain accurate and defensible post-treatment verification samples from the Passaic River. This task will be performed based on NJDEP/USEPA directives to verify that the encapsulation of the asbestos material is meeting the remediation objectives for OU-1. The contractor will collect, at a minimum, one grab sample and perform asbestos analysis using US EPA Method 100.2 respectively for year 2. For the remaining years, (Years 3-30) the number and frequency of sampling for asbestos analysis will be determined for each sampling event and sampling point.

4.2.2 Sampling Locations and Rationale

All post-remediation verification samples will be collected at the locations depicted in Figure 1-2 and tabularized in Table 3-1. The rationale for the selection of these points is to provide consistency with pre-construction, construction, and post-construction data.

Surface Water/Sediments. The post-remediation verification samples for surface water and sediment samples will be collected from the previously sampled locations SW/SD-1, SW/SD-2, SW/SD-3, SW/SD-4, and SW/SD-5. Sampling locations are presented in Figure 1-2. These locations have been chosen to provide consistency with pre-construction, construction, and post-construction activities.

In the event that a post-remediation sample fails to meet the Target Monitoring Guidelines for OU-1, re-sampling may be initiated during the next sampling event for the failed location upon Agency approval.

4.2.3 Sampling Collection Apparatus

All surface water samples collected during this monitoring program will be collected using laboratory supplied containers. The procedures for collection of samples using these devices are outlined in the EM200-1-3, Section C-3, Requirements for the Preparation of a Sampling and Analysis Plan (USACE, 1994) and the *Field Sampling Procedures Manual* (NJDEP, 1988).

4.2.4 Sample Collection Procedure

Generally, the contractor will follow the procedures below for the collection of surface water samples using the hand-held bottle method. Sediment and surface water sampling of the Passaic River will be performed starting at the most downstream location and moving upstream. Surface water will be collected before sediment. The specific sample collection procedures for discreet grab samples are as follows:

1. Spread a new piece of plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.

2. Submerge the sample container with the cap in place with minimal surface disturbance so that the open end is pointing upstream.

3. Allow the device to fill slowly and continuously using the cap to regulate the speed of the water entering the bottle.

4. Retrieve the sample container from the surface water with minimal disturbance.

5. Preserve the sample as necessary and verify that the pH is sufficient for the criteria of analysis.

6. Verify that a PTFE liner or equivalent is present in the cap. Secure the cap tightly.

7. Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all categories or parameters.

8. Place the filled sample container on ice immediately along with the required trip and field blanks, as necessary.

9. Record the information in the field logbook, field sheet and complete the chain-of-custody form documentation.

As field events dictate and state-of-the-art becomes available, modifications to the sampling process may be incorporated upon Agency approval.

4.2.5 Sample Preparation

The following procedure will be implemented for preparation of sample prior to shipment to the contract Laboratory:

- Each sample jar will inspected to ensure that the sample identification number matches the sample collection log and sample chain of custody.

- Each sample jar will be individually wrapped to ensure the structural integrity of the jar for shipment to the laboratory

- The wrapped sample will be stored in a cooler provided by the laboratory and maintained at Cool 4° C for shipment to the laboratory.

- Decontaminate sampling equipment.

Procedures presented above are for the collection of surface water samples for this activity. The list of equipment needed for surface water sampling is presented on Table 4-3 and a listing of the container requirements necessary to complete this task can be found in Table 4-4.

Field QA/QC samples, as described in SOP 18.1, located in Appendix A, may include field duplicate, split samples, and trip blanks. The duplicate and split samples will be collected after the record sample is collected.

4.2.6 Sample Documentation

All surface water sampling information for each sample will be recorded on a Sample Collection Field Sheet (Figure 4-1) including field instrument reading(s), if required. The following information will be recorded in a field logbook and on a FADL:

- Date/time of sampling
- Personnel present
- Sample location
- Sample number
- Sample depth and interval
- Chemical analysis required
- Other data as required.

Archived samples, if required, will be stored in on-site, samples-only, refrigerators at the field office for possible future analysis. The archived samples will be stored in accordance with SOP 19.1 at a maximum temperature of 4°C until shipped to a laboratory or disposed.

As part the archiving process, if required, control samples (field duplicates) will also be archived. Control samples will be submitted along with the archived samples for chemical analysis as specified in the site-specific SAPs.

Samples for chemical analysis will be handled as discussed in Chapters 5.0 and 6.0 of this SAP.

4.3 Sediment Sampling

This section presents procedures for collecting sediment samples from surface water sampling locations. Verification samples for this monitoring program will consist of collecting one grab sample collected from the areas listed in Table 3-1 and graphically represented in Figure 1-2.

4.3.1 Sampling Objectives

The sampling objective is to obtain accurate and defensible post-remedial sediment samples from the sampling locations along the Passaic River. The contractor will collect, at a minimum, one biannual grab sample from each location and perform asbestos analysis using US EPA Test Method for the Determination of Asbestos in Bulk Building materials, EPA/600/R-63/116, July 1993 for one year . Biannual results from the second year (initial sampling year) will be evaluated to determine sampling frequency thereafter.

4.3.2 Sampling Locations and Rationale

All post-remediation verification sampling will be conducted from the previously sampled locations along the Passaic River identified in Figure 1-2. The rationale for the sampling location is to provide consistency between the data collected during pre-construction, construction and post-construction.

In the event that a post-remediation verification sample fails to meet the Target Monitoring Guidelines for OU-1, re-sampling may be initiated during the next sampling event for the failed location upon Agency approval.

4.3.3 Sampling Collection Apparatus

All sediment samples collected during this monitoring program will be collected using disposable plastic or stainless-steel trowel/scoop. The procedures for collection of samples using these devices are outlined in the *EM200-1-3, Section C-5,* Requirements for the Preparation of a Sampling and Analysis Plan *(USACE, 1994)* and the *Field Sampling Procedures Manual* (NJDEP, 1988). All sample bottles will be prepared in accordance with the OSWER Directive 9240,0-05A "Specifications and Guidance for Contaminant-Free Sample Containers". All bottles will be packaged from the manufacturer with tamper evident custody seal and accompanied by a certificate of analysis for the corresponding batch.

4.3.4 Sample Collection Procedure

Generally, the contractor will follow the procedures below for the collection of sediment water samples using the scoop or trowel method. Sediment and surface water sampling of the Passaic River will be performed starting at the most downstream location and moving upstream. Surface water will be collected before sediment. The specific sample collection procedures for discreet grab samples are as follows:

1. Place plastic sheeting on the ground adjacent to the sampling location to prevent cross-contamination.

2. Sketch the sample area or note recognizable features for future reference.

3. Insert scoop or trowel into material and remove sample. Sediment samples shall be taken 0 to 6 inches below the water surface.

4. Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.

5. When homogenizing of the sample location is appropriate for the remaining analytical parameters the sample is transferred to the stainless-steel bowl for mixing.

6. Transfer sample into an appropriate sample bottle with a stainless-steel spoon or equivalent.
7. Check that a PTFE liner or equivalent is present in the cap. Secure the cap tightly.

8. Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.

9. Place filled sample containers on ice immediately.

10. Complete all chain-of-custody documents and field sheets and record in the field logbook.

11. Decontaminate sampling equipment after use and between sampling locations.

As field events dictate and state-of-the-art becomes available modifications to the sampling scope of work and the sampling procedures may be incorporated upon Agency approval.

4.3.5 Sample Preparation

The following procedure will be implemented for preparation of sample prior to shipment to the contract laboratory:

- Each sample jar will inspected to ensure that the sample identification number matches the sample collection log and sample chain of custody.

- Each sample jar will be individually wrapped to ensure the structural integrity of the jar for shipment to the laboratory

- The wrapped sample will be stored in a cooler provided by the laboratory and maintained at Cool 4° C for shipment to the laboratory.

- Decontaminate sampling equipment.

The list of equipment needed for sediment sampling is presented on Table 4-5 and a listing of the container requirements necessary to complete this task can be found in Table 4-6.

4.3.6 Sample Documentation

All sediment sampling information for each sample will be recorded on a Sample Collection Field Sheet (Figure 4-1) including field instrument reading(s), if required. The following information will be recorded in a field logbook and on a FADL:

- Date/time of sampling
- Personnel present
- Sample location
- Sample number
- Sample depth and interval
- Analysis required
- Other data as required.

4.4 Decontamination

This discussion presents procedures for decontamination of personnel and equipment. Decontamination of equipment and personnel will be performed for health and safety precautions, to avoid cross-contamination of sample material collected for chemical analysis, and to limit the migration of contaminants off-site and between on-site work areas.

4.4.1 Equipment Decontamination

Decontamination of equipment will occur at an area outside the area of the sampling activities or at a central decontamination station (if required).

Decontamination pads constructed at each sampling location shall be durable, portable, and capable of supporting all equipment to be decontaminated without risk of damage resulting in loss of rinsate. Decontamination pads will also be capable of containing all decontamination fluids for collection to a tank or drum.

Associated equipment used to collect samples will be decontaminated at the edge of the sampling area at the completion of each task to prevent cross contamination. All reusable equipment that may come in contact with samples for chemical analysis will be decontaminated between the collection of samples.

Cleaning will consist of scraping and scrubbing to remove encrusted materials, if necessary, followed by soap (Alconox) and water wash and then a potable water rinse. Alternatively, the equipment may be cleaned with a high-pressure hot water/steam-cleaning unit, if necessary.

Following decontamination, clean equipment will be allowed to air dry prior to obtaining the next sample.

4.4.2 Personnel Decontamination

Decontamination of personnel engaged in sampling activities will be performed at personnel decontamination stations established at the edge of the sampling areas. A personnel decontamination station will also be available at the central decontamination station (if required) for decontamination of field personnel.

Personnel decontamination will take place in both the central decontamination station (if required) and at the edge of sampling area prior to leaving these areas. Personnel decontamination will consist primarily of soap and water washings and water rinse of exterior protective gear to remove contaminants followed by removal of gear. The extent of washing required, or modifications to the sequence, will be specified by the SSHO. Coveralls should be removed by turning the clothing inside out. The steps for decontamination of personnel are as follows:

1. Wash work gloves, boots and outer protective coverall (if water-resistant).
2. Remove tape at wrists, ankles.
3. Rinse work gloves, boots and coverall (if water-resistant).
4. Remove outer resistant gloves
5. Remove goggles, respirator mask or breathing mask.
6. Wash and rinse goggles or mask.
7. Remove outer suit.
8. Remove PVC or rubber boots (if worn).
9. Remove surgical gloves.

Non-reusable equipment and clothing will be collected in plastic trash bags. Disposal of all investigation derived waste associated with decontamination activities will be in accordance with Chapter 7.0, *Investigation Derived Waste*, of this SAP.

Respirators will be rinsed with potable water in the field after each use and will be cleaned at the end of each day using a cleaning solution as recommended by the manufacturer followed by a potable water rinse. Respirators will be inspected daily for damage, missing parts, and proper function.

5.0 Chain of Custody/Documentation

During field sampling activities, samples must be maintained from the time the samples are collected, until laboratory data is issued, and samples are appropriately disposed. Initial information concerning collection of the samples will be recorded in a field logbook and on a FADL. Information regarding the custody-of-custody (COC), transfer, handling, and shipping of all samples will be recorded on an Analysis Request and Chain-of-Custody Record (Figure 5-1a and 5-1b). Refer to the SOP 1.1 provided in Appendix A for complete step-by-step Chain of Custody procedure.

The sampler will be responsible for initiating and filling out the Analysis Request and Chain-of-Custody Record. The field team members are responsible for the care and custody of the samples collected until the samples are transferred to another individual or shipped to the analytical laboratory. The field team, under the direction of the Field Supervisor, is responsible for enforcing COC procedures during fieldwork. The Analysis Request and Chain-of-Custody Record will be signed, with date and time, by the sampler when samples are relinquished to anyone else. Analysis Request and Chain-of-Custody Records will accompany the samples at all times. All individuals who subsequently take possession of the samples will also sign, with date and time, the Analysis Request and Chain-of-Custody Records. The Analysis Request and Chain-of-Custody Record will accompany each cooler containing samples sent to the analytical laboratory. Laboratory personnel are responsible for the receipt and entry of samples into the laboratory, which have been submitted under a COC document. Additionally, samples received will be entered into the laboratory COC procedures by properly documenting and maintaining COC from the moment that they take custody of the sample until the sample is properly disposed of.

5.1 Field Logbook/Field Activity Daily Log

Field logbooks and FADLs will be maintained to record all pertinent information. A description of the type of information to be recorded for the various field activities is provided in the applicable SOP presented in Chapter 4.0 of this SAP. Entries will be as descriptive and detailed as possible so that a particular situation can be reconstructed without reliance on the collector's memory. Field logbooks (which will consist of a permanently bound book with consecutively numbered pages) and FADLs (Figure 5-2) will be kept by the site engineer and each sampling team leader.

The cover of each field logbook will contain the following information:

- Project name and number
- Book number
- Activity type
- Start date
- Stop date.

Entries to a field logbook will be made and a FADL completed daily. At a minimum, the information provided will consist of the following:

- Date
- Start time
- Weather
- All field personnel present
- Visitors to the site (time, name, and company)
- Level of personnel protection used
- Type of activity conducted
- Sampling location
- Sample identification number
- Description of sampling point
- Method of sampling
- Type of sample
- Air monitoring readings, if applicable
- Pertinent field observations
- Instrument identification numbers
- Results of field instrument calibration
- Field measurements
- Anticipated disposition of sample
- Description of all related activities
- Signature of the person making the entry.

All measurements made and samples collected will be recorded. All entries will be made in indelible ink. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark and initialed. Entries will be organized into easily understandable tables, if possible.

At each station where a sample is collected or a measurement made, a detailed description of the location of the stations will be recorded. All equipment used to make measurements will be identified, including the date on which the equipment was calibrated.
In addition, the Field Supervisor will maintain a daily field summary book. Entries into this book will include:

- Types of activities conducted throughout the day
- Personnel involved with each activity
- Description of instructions given to field personnel
- Health and safety related problems and corrective measures taken
- Summary of discussions with the project managers
- List of site visitors with purpose for the visit
- Changes/modifications to sample locations or procedures
- Any other pertinent information related to site activities.

Field documentation requirements for the SSHO are presented in the SSHP.

5.2 Photographs

At a minimum, color photographs will be taken, prior to and after conducting field activities. Additional photographs may be taken during the activity and at the request of the Contract Lead Technician or NJDEP/USEAP field representative. Photographs will be accompanied with a numbered photograph log that will include the project name, date, and description of activity (e.g., surface water sampling and corresponding sample identification number).

5.3 Sample Numbering System

Standard Operating Procedure 17.2, located in Appendix A, provides the standard procedures for sample numbering. Additional information to be provided in the sample number will be a specific OU-1 designation from which the sample was collected. Each sample collected for chemical analysis, or archived for possible future analysis, will be placed in the appropriate container(s) and labeled at the time of sample collection with the following information:

- Project number and name
- Sample number
- Date and time of collection
- Required analyses and methods
- Type of preservative
- Volume of sample and container type.

The sample numbering system will provide a tracking number to allow retrieval of the sample and exact identification of the sample location. The following number system will be used for identification of the samples at the site.

5.3.1 Sample Type

Each type of sample collected will be identified by a two-letter prefix code as follows:

- MW - Groundwater
- SW - Surface Water
- SD – Sediment.

5.3.2 Sample Location

A six-digit numeric designation will follow the sample type prefix to identify the date of sample collection. For example, MW-061270-901 indicates a groundwater sample collected on June 12, 1970 was collected from monitoring well 901. For surface water and sediment samples, an two-digit numeric designations will be used to distinguish individual sampling locations, for example, SW-061270-01 indicates that a surface water sample was collected on June 12, 1970 from sampling water sampling point SW-01.

Sample Depth. Where applicable, the sample identification number will include a number following the sample type and location prefixes to identify the depth of the sample.

5.4 Sample Documentation

Sample documentation will be conducted in accordance with the following subsections.

5.4.1 Sample Labels and/or Tags

Standard Operating Procedure 17.1, located in Appendix A, provides the necessary procedures to properly label samples. Each sample collected for chemical analysis, or archived for possible future analysis, will be placed in the appropriate container(s) and labeled at the time of sample collection with the following information:

- Project number and name
- Sample number
- Date and time of collection
- Required analyses and methods

- Type of preservative, if applicable
- Volume of sample and container type.

5.4.2 Sample Field Sheets and/or Logbooks

Field sheets and logs to be used to document pertinent information associated with the various field activities and sample types are presented on Table 5-1. Additional forms and documents will be prepared and utilized as required.

5.4.3 Chain of Custody Records

The COC procedures are presented in SOP 1.1 and summarized as follows:

- At the time of sample collection, the Analysis Request and Chain-of-Custody form is completed for the sample collected.

- When the form is full or when all samples have been collected that will fit in a single cooler, the field team members will crosscheck the form for possible errors. Corrections are made to the record with a single strike mark and dated and initialed. All entries will be made in blue or black ink. The Analysis Request and Chain-of-Custody Record will be signed when the samples are relinquished.

- If shipping samples to a laboratory off-site, a shipping bill is completed and the shipping bill number recorded in the Analysis Request and Chain-of-Custody Record prior to enclosing inside a clear plastic bag and attaching it to the inside of the cooler lid.

When transferring custody of the samples, the individual relinquishing custody of the samples will verify sample numbers and condition and will document the sample acquisition and transfer by signing, with date and time, the Analysis Request and Chain-of-Custody Record. The field sample coordinator will assist the samplers in grouping the samples for shipment to the analytical laboratory and review the completed Analysis Request and Chain-of-Custody Record for each cooler of samples. Samples will be packaged for shipment and dispatched to the analytical laboratory with a separate Analysis Request and Chain-of-Custody Record accompanying each cooler.

Custody seals will be used to ensure that the shipping containers have not been opened during shipment and prior to receipt at the off-site laboratory. The following information will be included on the custody seals:

- Signature of the sample coordinator
- Date when the sample package is sealed.

All seals will be completed using indelible ink. The seals will be affixed to the front and back of the cooler, at the interface of the cooler and the lid. The placement of the seals will be in a manner that breaking the seals would be necessary in order to open the sample shipping cooler.

In conjunction with data reporting, the analytical laboratory will return the original or a photocopy of the original Analysis Request and Chain-of-Custody Record to the field office for inclusion into the project file.

All samples collected will remain in the possession of the sampling crew until shipment. Locked vehicles or trailers will be used for interim storage if necessary. If coolers (used for sample storage) must be left unattended for extended periods of time, signed custody seals will be placed on the front and back of each cooler or the cooler will be stored under lock until shipped to the off-site laboratory.

5.4.4 Sample Receipt Forms

When the analytical laboratory receives the sample coolers, a receipt for sample for will be initialed. An example of this form can be found as Figure 5-2 in Part II (i.e., QAPP) of this SAP. This form will document the sample condition upon receipt. All receipt nonconformance situations will be initiated through the use of this form.

5.5 Documentation Procedures

The original page of each Analysis Request and Chain-of-Custody form will be sent with the samples to the laboratory, and the copy will be retained by the sampling team and placed in the project files. For sample packages sent by carrier to a laboratory off-site, bills of lading will be retained as part of the documentation for the COC records.

6.0 Sample Packaging and Shipping

This chapter describes packaging and shipping procedures for environmental samples collected during investigations or other sampling activities. Samples will be shipped off-site according to applicable guidance documents and U.S. Department of Transportation (DOT) regulations found in 49 CFR Parts 171 through 180. To minimize sample container breakage and provide adequate sample temperature during shipment, sample containers will be prepared and packaged according to the following procedures. A copy of the specific standard operating procedure is presented in SOP 2.1, found in Appendix A.

- Secure sample bottle lids. Ensure that the sample label is securely attached by placing clear tape over the label.
- Place custody tape over the sample container lid or cap.
- Place sample bottles in Styrofoam sleeves (if provided); or place sample bottles in resealable clear plastic bags and wrap them with protective packing material.
- Tape the drain hole shut on the inside and outside of a waterproof metal (or equivalent strength plastic) cooler.
- Line the sides and floor of the cooler with protective packing material.
- Line the cooler with a large plastic bag.
- Place containers upright in the cooler in such a way that they do not touch.
- Packing material will be placed in appropriate locations to minimize potential container breakage during shipment. Care will be taken so that the packing material does not thermally insulate the containers from the ice placed in the shipping container.
- Pack the area surrounding the samples with ice (either chemical ice packs or ice cubes sealed in plastic bags).
- Fill the remaining space in the cooler with cushioning material.
- Close the large plastic bag in the cooler and tape or secure shut.
- Place the completed Analysis Request and Chain-of-Custody form and other paperwork in a sealed, clear plastic bag and tape the bag to the inside lid of the cooler.

- Wrap the cooler completely around with strapping tape at two locations. Do not cover any labels.
- Place the address label of the shipment destination on top of cooler.
- Affix signed custody seals on the cooler at the interface between the cooler and the lid, both in the front and back sides. Cover the seals with wide, clear tape.
- Make a copy of the shipping air bill for the project file and place the original in a clear envelope secured to the outside of the cooler lid.

Samples will be sent to an off-site laboratory by use of an overnight courier delivery service. Prior to shipment of samples, arrangements will be made with the laboratory to receive and analyze the samples.

Laboratory specific receiving and handling procedures will be described in the Laboratory Quality Assurance Plans.

7.0 Investigation Derived Waste

Historical investigations have identified investigation-derived wastes (IDW) to be of low contaminant concentration levels. It is anticipated that additional investigations will generate similar wastes. This chapter provides general information for the management, minimization, and protection of the environment from wastes generated during field activities.

7.1 Waste Management

Management of IDW from general site activities will be performed in accordance with the NJDEP and USEPA requirements for disposal.

7.2 Waste Minimization

Waste handling, storage treatment and final disposition will be planned before an activity handles or generates waste. Waste minimization will involve the following objectives:

- Plan for incorporating waste into anticipated final remedies for the operable unit, when possible
- Minimize volume by cleaning, compacting, drying, and decanting
- Separate soil waste media from water waste
- Plan not to mix contaminant in containers; segregate wastes by contaminants
- Clean contaminated Personal Protective Equipment (PPE) if possible and dispose as solid municipal waste if necessary
- Use waste minimization as a design criterion and for planning for design life cycles, per USEPA directives
- When possible, budget final waste disposal costs within each activity budget and each activity schedule to avoid accumulating waste.

7.3 Environmental Protection

As a general compliance policy, discharges to the air, water, and soil will be minimized. Uncontaminated areas will not be contaminated by remediation activities; spreading of contaminants will be minimized. Aquifers will be isolated from contaminants and opening new pathways for contaminants will be avoided. Activities will avoid disturbance of biota and

habitat, per the National Environmental Policy Act (NEPA) 40 CFR 1500, *Council on Environmental Quality - Purpose, Policy, and Mandate*.

8.0 Contractor Quality Control

The Prime Contractor (designated by NJDEP) is responsible for ensuring quality is maintained throughout all field operations. The use of the three-phase control process has been employed on previous field exercises to control field activities. Preparatory, initial, and follow-up inspections are performed by the contractor to control all operations. The quality control plan is included as Part II of this SAP.

Preparatory inspections shall be conducted prior to the sampling event and assure that all personnel are knowledgeable of the FSP and QAPP and that all materials and equipment for sampling are available for the event. Initial inspections shall be conducted during the beginning of the sampling event to assure that sampling protocols and procedures are being followed. Final inspections during and after the sampling event shall be conducted to assure that all documentation has been properly prepared for the sampling event.

A detailed discussion of the three-phase inspection process is presented in the document *Construction Quality Management for Contractors* (USACE, 1997). A three-phase inspection will be performed for sampling and analysis as a single definable feature of work. Inspection of sampling and analysis will include: Review of contract requirements, review of applicable drawings and submittals, review of frequency and type of tests being performed, material and equipment needed, subcontractor requirements, and schedule.

9.0 Quality Control Reports

During field activities, QCRs (Quality Control Reports) will be prepared daily. Each QCR will be dated, signed by the PM, and sent to the NJDEP/USEPA-designated POC on an as needed basis. The reports will include the following:

- Weather information at the time of sampling
- Field instrument measurements
- Field instrument calibrations
- Field Work Variances
- Problems encountered during sampling
- Instructions received from regulatory personnel.

Any deviations that may affect the ability to meet objectives of the investigations will be conveyed to the NJDEP/USEPA-designated POC immediately. The following information may be attached to the QCRs:

- Field Analytical QA/QC Information
- FADLs or copies of applicable pages from field logbooks
- Copies of the Analysis Request and Chain-of-Custody forms
- Field sample collection sheets.

At the completion of the operation and maintenance monitoring period, these reports will be filed as final to reside in the final closure plan record for OU-1.

10.0 Corrective Actions

Corrective actions may be required for two major types of problems: analytical/equipment problems and noncompliance with criteria. Analytical and equipment problems may occur during sampling, sample handling, sample preparation, laboratory instrumental analysis, and data review.

10.1 General Field Issues

Noncompliance with specified criteria and analytical/equipment problems will be documented through a formal corrective action program at the time the problem is identified. The person identifying the problem is responsible for notifying the PM, CQCM, who in turn will notify the NJDEP/USEPA PM. When the problem is analytical in nature, information on these problems will be promptly communicated to the Project Chemist. Implementation of corrective action will be confirmed in writing.

Any nonconformance with the established procedures will be identified and corrected in accordance with in this chapter. The CQCM or designee will issue an NCR for each nonconforming condition (Figure 10-1).

Corrective actions will be implemented and documented in a field record book or on a FADL, and in the NCR. No staff member will initiate corrective action without prior communication of findings through the PM. If corrective actions are deemed insufficient, work may be stopped through a stop-work order issued by the CQCM or PM and the NJDEP/USEPA PM.

10.2 Sample Collection/Field Measurements

Technical staff and project personnel will be responsible for reporting all suspected technical and QA nonconformance issues or suspected deficiencies of any activity or issued document by reporting the situation to the PM or CQCM. The CQCM will be responsible for assessing the suspected problems in consultation with the PM to make a decision based on the potential for the situation to impact the quality of the data. When it is determined that the situation warrants a reportable nonconformance and corrective action, then an NCR will be initiated by the CQCM.

The PM will be responsible for ensuring that corrective actions for nonconformance issues are initiated by:

- Evaluating all reported nonconformances
- Controlling additional work on nonconforming items
- Determining disposition or action to be taken
- Reviewing NCRs and corrective actions taken
- Ensuring that NCRs are included in the final site documentation project files.

If appropriate, the PM will ensure that no additional work associated with the nonconforming activity is performed until the corrective actions are completed.

Corrective action for field measurements may include:

- Repeating the measurement to check the error
- Checking for all proper adjustments for ambient conditions such as temperature
- Checking the batteries
- Re-calibrating equipment
- Checking the calibration
- Modifying the analytical method including documentation and notification (i.e., standard additions)
- Replacing the instrument or measurement devices
- Stopping work (if necessary).

The PM or designee is responsible for all site activities. In this role, the PM may at times be required to adjust the site activities to accommodate site-specific needs. When it becomes necessary to modify an approved procedure, the responsible person will notify the PM of the anticipated change and implement the necessary changes after obtaining the approval of the PM, and the NJDEP/USEPA PM. All changes to an approved procedure will be documented on the FWV form (Form 10-2) that will be signed by the initiators and the PM. The FWV for each document will be numbered serially as required. The FWV shall be attached to the file copy of the affected document. The PM must receive approval in writing from the NJDEP/USEPA prior

to field implementation. If unacceptable, the action taken during the period of deviation will be evaluated in order to determine the significance of any departure from established program practices and action taken.

The CQCM is responsible for the controlling, tracking, and implementation of the identified changes. Reports on all changes will be distributed to all affected parties, including the NJDEP/USEPA PM and controlled document holders (e.g., regulatory agencies). The NJDEP/USEPA will be notified whenever procedure changes in the field are made.

11.0 Project Schedule

Initiation of the field activities is scheduled once approval is granted and will continue until completion of the activity or inclement weather forces a cessation of the field activities.

12.0 Sampling Apparatus and Field Apparatus

This chapter describes procedures for maintaining the accuracy of all the instruments and measuring equipment used for conducting field tests and analyses. These instruments and equipment shall be calibrated before each use or on a scheduled, periodic basis according to manufacturer's instructions.

12.1 Field Instruments and Equipment

Instruments and equipment used to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications. All field instruments for this purpose will have unique identifiers and each instrument will be logged in a field logbook or on a FADL before use in the field. Calibration procedures and maintenance schedules for various pieces of field equipment are summarized on Table 12-1. The SSHO or designee will be responsible for performing and documenting daily calibration/checkout records for all health and safety related instruments used in the field.

Equipment to be used during field sampling will be examined to certify that it is in operating condition. This will include checking the manufacturer's operating manual and instructions for each instrument to ensure that all maintenance requirements are being observed. Field notes from previous sampling events will be reviewed so that the notation on any prior equipment problems will not be overlooked, and all necessary repairs to equipment will be carried out. Spare parts or duplication of equipment will be available for the field activities.

Calibration of field instruments will be conducted at a minimum daily prior to the sampling event and will be governed by the manufacturer or more frequently as conditions dictate. Calibration procedures and frequency will be recorded on a FADL and in a field logbook.

Field instruments will include a pH meter, temperature probe, and conductivity meter. If an internally calibrated field instrument fails to meet calibration/checkout procedures, it will be returned to the manufacturer for service and a back-up instrument will be calibrated and used in its place. Field instrument uses, detection levels, and calibration are summarized on Table 12-2.

Detailed instructions on the proper calibration and use of each field instrument follow the guidelines established by the manufacturer. The technical procedures for each instrument used on this project include the manufacturer's instructions detailing the proper use and calibration of each instrument.

12.2 Preventative Maintenance

The field equipment for this project includes a pH meter, temperature probe and a specific conductance meter. Specific preventative maintenance procedures to be followed for field equipment are those recommended by the manufacturers. These procedures are included in the technical procedures governing the use of these instruments. Table 12-1 provides typical requirements necessary for control of field instrumentation.

Field instruments will be checked and/or calibrated before they are shipped or carried to the field. Each field instrument will be checked daily against a traceable standard or reference with a known value to ensure that the instrument is in proper calibration. Instruments found to be out of calibration will be re-calibrated before use in the field. If the instrument cannot be calibrated, it will be returned to the supplier or manufacturer for re-calibration, and a back-up instrument will be used in its place. Calibration checks and calibrations will be documented on FADLs or in a logbook. Any maintenance conducted on field equipment must be documented on a FADL.

Critical spare parts such as electrodes, and batteries will be kept at the project office and carried into the field to minimize down time of malfunctioning instruments. Back-up instruments and equipment should be available on site or within 1-day shipment to avoid delays in the field schedules.

13.0 References

Camp Dresser McKee, Federal Programs Corporation (CDM), February 12, 1996, *Revised Sampling and Analysis Plan, Asbestos Dump- Millington Site*

New Jersey Department of Environmental Protection (NJDEP), 1992, *Field Sampling Procedures Manual*

National Environmental Policy Act (NEPA) 40 CFR 1500, *Council on Environmental Quality - Purpose, Policy, and Mandate*

U.S. Army Corps of Engineers (USACE), 1994, EM 200-1-3, Requirements for the Preparation of Sampling and Analysis Plans

Tables

TABLE 1-0
MONITORING WELLS GROUNDWATER ELEVATIONS

Inspection Date: _____
Inspected By: _____

Asbestos Dump OU-1 Superfund Site
Millington Asbestos Dump Site
Millington, Morris County, New Jersey

Sample Location	NJ Permit Number	Top of Outer Well Casing Elevation (ft)	Top of Inner Well Casing Elevation (ft)	Depth to Water (ft)	Groundwater Elevation (ft)
MW-901	2528291	270.15			
MW-902	2528292	254.4	253.6		
MW-903	2528290	253.9	253.4		
MW-904	2528289	252.3	252.0		
MW-905	2528294	220.9	220.5		
MW-906	**	261.0	260.9		
MW-907	**	225.3	224.4		

** - No permit numbers were found on these well casings.

Table 1-1
Previous Remedial Investigation Results, Groundwater Samples
Millington Asbestos Dump Superfund Site
Millington, New Jersey
(Microgram / Liter)

	Groundwater Sample ID	MW901			MW902			MW903			MW904			MW905			MW906			MW907			MW908 (DUPLICATION OF MW905)		
Analyte	Date	10/14/86	6/22/87	10/19/87	10/14/86	6/22/87	10/19/87	10/10/86	6/22/87	10/19/87	10/14/86	6/22/87	10/20/87	10/14/86	6/22/87	10/19/87	10/10/86	6/22/87	10/19/87	10/10/86	6/22/87	10/19/87	10/14/86	6/22/87	10/19/87
Volatile																									
Organics	1,1,1 Trichloroethane	--	U	--	--	--	--	--	--	--	--	--	--	--	U	--	--	U	--	--	U	--	--	U	--
	1,2 Dicholorethene	--	U	--	--	--	--		4J	--		1J	--		U	--		U	--		U	--		U	--
	Acetone	--	U	67	--	12	--	--	17	17	--	NDB	--	--	U	--	--	U	--	--	U	--	--	U	--
	Benzene	--	U	2.63	--	NDB	--	--	NDB	--	2J	NDB	--	--	U	--	--	U	--	--	U	--	--	U	--
	Chloroform	--	U	--	--	--	--	NDB	--	--	NDB	--	--	NDB	U	--	--	U	--	NDB	U	--	NDB	U	--
	Ethyl Benzene	--	U	21	--	--	50	--	--	--	--	--	--	--	U	--	--	U	1.2J	--	U	--	--	U	--
	Methylene chloride	--	U	--	--	--	--	NDB	2J	--	NDB	--	--	NDB	U	--	NDB	U	--	NDB	U	--	NDB	U	--
	Toluene	--	U	--	--	--	2.5J	--	--	--	--	--	--	2J	U	--	--	U	--	--	U	--	--	U	--
	Trans-1,2 Dichloroethene	--	U	--	--	--	--	6	--	5.8	--	--	--	--	U	--	--	U	--	--	U	--	--	U	--
	Trichloroethene	--	U	--	--	--	--	3J	--	4.9	--	--	2	6	U	2.9	--	U	--	--	U	--	6	U	--
	Trichlorofluromethane	--	--	--	--	--	--	--	--	--	--	--	0.5J	--	--	--	--	--	NDB	--	--	--	--	--	--
	Xylenes (total)	--	U	9.3	--	--	--	--	--	--	--	--	--	--	U	--	--	U	--	--	U	--	--	U	--
Base																									
Neutrals	2-Methylnaphthalene	--	U	1.2J	--	--	--	--	--	--	--	--	--	--	U	--	--	U	--	--	U	--	--	U	
	Bis(2-ethylhexyl)phthalate	140	U	17	180	2J	NDB	--	6J	--	400	--	NDB	--	U	NDB	--	U	NDB	--	U	NDB	83	U	
	Butyl benzyl phthalate	--	U	--	9J	--	--	--	--	1.0J	2J	--	--	--	U	--	--	U	--	--	U	--	--	U	
	Di-n-butyl phthalate	--	U	1.2	3J	NDB	1.0J	--	NDB	NDB	5J	NDB	NDB	--	U	--	1J	U	--	--	U	--	--	U	
	Di-n-octyl phthalate	U	U	--	U	--	--	U	--	--	U	--	--	--	U	--	--	U	--	--	U	--	U	U	
	Fluoranthene	--	U	--	--	--	--	--	--	--	--	1J	--	--	U	--	--	U	--	--	U	--	--	U	
	Napthalene	--	U	2.6	--	--	--	--	--	--	--	--	--	--	U	--	--	U	--	--	U	--	--	U	
Pesticides/																									
PCBs	Endrin	0.026	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dissolved																									
Metals	Arsenic	--	--	--	--	[6.2]R		--	--		--	--		--	--		--	--		--	--		--	--	
	Cadmium	--	--	--	--	--		--	--		--	--		--	--		--	--		--	--		--	--	
	Chromium	--	15	11	--	11		--	20		--	30		--	19		--	11		--	20		--	--	
	Copper	--	--	[22]	--	--		--	--		--	[10]		--	--		--	89		--	--		--	--	
	Lead	--	[2.8]	--	--	--		--	25SR		--	[3.6]QR		--	--		--	--		--	--		--	--	
	Mercury	0.3	--	--	1.2	3.4		0.2	--		--	--		5.6	--		2.1	--		2.5	--		6.9	--	
	Nickel	--	[29]	[14]	--	--		--	--		--	--		--	142		--	--		49N	--		--	--	
		--	--	--	--	15		--	[9.0]R		--	11R		--	13R		--	12R		--	24R		--	--	
	Zinc	28	[17]	36	57N	[9.8]ER		28	[12]ER		52	[14]ER		87N	33RE		96N	[12]ER		108N	[12]RE		74	--	
Total																									
Metals	Arsenic	--	--	--	--	--	[7.0]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Cadmium	--	--	19	--	--	--	--	--	--	--	--	--	--	--	--	--	--	[4.3]	--	--	--	--	--	--
	Chromium	--	--	--	--	--	[10.0]	--	--	17	--	--	15	--	--	94	--	--	268	--	--	11	--	--	81
	Copper	--	--	[14]	--	--	[10.0]	--	--	[12]	--	--	[10]	--	--	35	--	--	10,900.00	--	--	[9.0]	--	--	31
	Lead	--	--	--	--	--	--	--	--	--	--	--	--	--	--	23.0NS	--	--	568.0N	--	--	--	--	--	21N
	Mercury	--	--	--	--	--	2.6	--	--	--	--	--	--	--	--	4	--	--	10	--	--	--	--	--	3.2
	Nickel	--	--	[15]	--	--	--	--	--	--	--	--	--	--	--	71	--	--	85	--	--	--	--	--	61
	Selenium	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Zinc	--	--	24	--	--	--	--	--	--	--	--	--	--	--	73	--	--	1178	--	--	24	--	--	75
Phenols		31	--	--	--	--	--	18	--	--	22	--	--	19	--	--	48	--	--	23	--	--	11	--	--
Asbestos		<100,000	<50,000	<50,000	<100,000	79,809	58,800	<100,000	88210	142000	<100,000	unread	<50,000	<100,000	unread	<50,000	unread	unread	<200,000	unread	unread	<200,000	unread	unread	<200,000

Table 1-2
Previous Remedial Investigation Results, Surface Water Samples
Asbestos Dump Superfund Site
Millington, New Jersey
(Micrograms/ Liter)

	Surface Water Sample ID	SW-1			SW-2			SW-3			SW-22			SW-00		
Analyte	Date	9/10/86	6/22/87	10/20/87	9/10/86	6/22/87	10/20/87	9/10/86	6/22/87	10/20/87	9/10/86	6/22/87	10/20/87	9/10/86	6/22/87	10/20/87
Volatile																
Organics	Acetone	--	--	--	--	--	--	--	NDB	--	--	--	NDB	--	U	--
	Benzene	--	NDB	--	--	NDB	--	--	--	--	--	NDB	NDB	--	U	NDB
	Methylene chloride	--	--	--	--	--	--	--	--	--	--	--	NDB	--	U	3.1
Phenols		--	--	--	--	--	--	--	--	--	42	--	--			--
Base																
Neutrals	Bis(2-ethylhexyl)phthalate	--	--	NDB	NDB	--	NDB	NDB	--	NDB	1J	--	--	--	U	NDB
	Diethyl phthalate	--	--	--	NDB	--	--	--	--	--	--	--	--	--	--	--
	Di-n-butyl phthalate	--	NDB	NDB	--	NDB	NDB	110	NDB	NDB	--	NDB	--	--	U	--
	Di-n-octyl phthalate	--	--	--	--	--	--	13	--	--	--	--	--	--	--	--
Total																
Metals	Arsenic	--	--	--	--	--	--	--	--	--	--	--	--	--	15R	--
	Antimony	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Cadmium	563	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Chromium	20N	--	5	--	26	--	--	11	5	--	--	--	--	--	--
	Copper	--	--	8	--	--	8	--	--	10	--	--	--	--	[14]	8
	Lead	--	[2.8]	--	--	[2.8]RQ	--	--	[2.5]RQ	--	18S	--	--	--	8.6SR	--
	Mercury	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Nickel	47N	--	--	--	--	--	--	--	--	84	--	--	--	[24]	--
	Selenium	--	--	--	--	--	--	--	--	--	--	--	20	--	--	--
	Silver	--	--	--	--	--	--	--	--	--	--	13R	--	--	--	--
	Zinc	--	[12]	14	--	[12]ER	49	--	--	11	--	[16]ER	60	--	40ER	36
Asbestos		<100,000	<100,000	67,200	<100,000	<100,000	71,400	100,000	<100,000	<50,000	<100,000	<50,000	<50,000	--	<100,000	<200,000

Table 1-3
Previous Remedial Investigation Results, Sediment Samples
Asbestos Dump Superfund Site
Millington, New Jersey
(Micrograms/ Liter)

	Sediment Sample	SED-1	SED-2
Analyte	Date	9/11/86	9/11/86
Volatile			
Organics	Benzene	--	1J
	Chloroform	2JB	4JB
	Methylene chloride	NDB	NDB
	Toluene	12B	15B
Base	Acenaphtene	16J	14J
Neutrals	Acenaphthylene	--	32J
	Anthracene	55J	82J
	Benzo(a)anthracene	--	660
	Benzo(a)pyrene	150J	590
	Benzo(b)fluoranthene	--	1300
	Benzo(g,h,i)perylene	--	500
	Benzo(k)fluoranthene	--	170J
	Bis(2-ethylhexyl)phthalate	140JB	130JB
	Chrysene	--	--
	Diethyl phthalate	--	--
	Diethyl phthalate	51J	54J
	Di-n-butyl phthalate	52JB	81JB
	Di-n-octyl phthalate	--	--
	Fluoranthene	400	1400
	Fluorene	20J	28J
	Ideno(1,2,3,c,d)pyrene	--	460
	Napthalene	--	8J
	Phenanthrene	210J	560
	Pyrene	320J	1200
Phenols		--	1
Pesticide/PCB	Heptachlor	5.7J	--
Total	Arsenic	--	10.9
Metals	Antimony	--	--
	Cadmium	--	--
	Chromium	25.6	29.2
	Copper	29.2*	67.2*
	Lead	33.2R	62.0R
	Mercury	--	0.36
	Nickel	32.1*	28.8*
	Selenium	--	--
	Silver	--	--
	Zinc	108	181
Asbestos		--	--

Table 1-4
Remedial Investigation Nomenclature
Asbestos Dump Superfund Site
Millington, New Jersey

Symbol	Definition
--	Below laboratory detection limits
J	Indicates that the concentration listed is an estimated value which is less than the specified minimum lower limit but is greater than zero
B	Analyte was found in the method blank as well as in the sample
N or R	Indicates spike recovery is not within control limits
	Blank space indicates that the sample was not analyzed for that parameter
NDB	Value is reported as not detected because compound was not found at concentrations less than five times (ten times for common lab contaminants) the amount in any blank associated with the sample
[ ]	Data is unusable due to method blank associated above CLP limits
Q	Indicates analytical spike is not within 85% to 115% control limits for values
E	Indicates a value estimated or not reported due to the presence of interference
S	Indicates value determined by Method of Standard Addition

Table 1-5
Target Monitoring Guidelines
Surface Water
Asbestos Dump Superfund Site
Operable Unit No. 1
Millington, New Jersey

ARARs and Other Guidance to be Considered for Surface Water (a)

(µg/L)

	ARARs						TBCs				Level of Concern	
	USEPA Water Quality Criteria (b)				N.J. Surface Water Quality Criteria (FW-2) (c)		USEPA Region III Tap Water RBCs (d)				Site Characterization/Prioritization	
			Human Health Risk for Consumption of:									
Chemical	Acute	Chronic	Water & Organisms	Organisms Only	SWQC		Non-carcinogen	Carcinogen $1x10^{-6}$	Carcinogen $1x10^{-4}$	C/N	LOC (e)	LOC Chosen
Asbestos (ak)	---	---	7,000,000	---	7,000,000	[h][1]	---	---	---	-	7,000,000	Water & Organisms, SWQC

RBC = Risk Based Concentration
SWQC = Surface Water Quality Criteria
TBC = To Be Considered
--- = No value available.
(c) NJDEP (1996). Surface water quality criteria fall into one of six categories: acute aquatic life criteria, chronic aquatic life criteria, noncarcinogenic effects-based human health criteria, carcinogenic effects-based human health criteria,
(d) USEPA (2000). USEPA Region III Risk Based Concentrations (RBCs) for consumption of tap water and inhalation while showering. These values are residential exposures based on 350 days/year.
(e) LOC is the lowest value from USEPA Water Quality Criteria and NJ Surface Water Quality Criteria. Only in the absence of water quality criteria is a Region III Tap Water (10^{-6}) RBC selected as the LOC.
(h) USEPA Water Quality Criteria and N.J. Surface Water Quality Criteria value for 1,3-dichloropropene.

Table 1-5 (Continued)
Target Monitoring Guidelines
Groundwater
Asbestos Dump Superfund Site
Operable Unit No. 1
Millington, New Jersey

(µg/L)

	ARARs					TBCs					Level of Concern	
	Federal Drinking Water Standards (b)		New Jersey Drinking Water	New Jersey Groundwater (c)		Federal Drinking Water Health Advisories (b)	USEPA Region III Tap Water RBCs (d)				Site Characterization/ Prioritization	
Chemical	MCL	MCLG	NJMCL	Quality Criteria	NJPQL	HA	Non-carcinogen	Carcinogen $1x10^{-6}$	Carcinogen $1x10^{-4}$	C/N	LOC (e)	LOC Chosen
Asbestos (af)	7,000,000	7,000,000	---	7,000,000	100,000	---	---	---	---	-	7,000,000	MCL, Quality Criteria, MCLG

RBC = Risk Based Concentration
SWQC = Surface Water Quality Criteria
TBC = To Be Considered
--- = No value available.
(b) USEPA (1999). National Recommended Water Quality Criteria- Correction. These water quality criteria are the USEPA's current recommended criteria, reflecting the latest scientific knowledge as required by Section 304(a)(1) of the Clean
(c) NJDEP (1996). Surface water quality criteria fall into one of six categories: acute aquatic life criteria, chronic aquatic life criteria, noncarcinogenic effects-based human health criteria, carcinogenic effects-based human health criteria,
(d) USEPA (2000). USEPA Region III Risk Based Concentrations (RBCs) for consumption of tap water and inhalation while showering. These values are residential exposures based on 350 days/year.
(e) LOC is the lowest value from USEPA Water Quality Criteria and NJ Surface Water Quality Criteria. Only in the absence of water quality criteria is a Region III Tap Water (10^{-6}) RBC selected as the LOC.
(h) USEPA Water Quality Criteria and NJ Surface Water Quality Criteria value for 1,3-dichloropropene.

Table 1-5 (Continued)
Target Monitoring Guidelines
Sediment
Asbestos Dump Superfund Site
Operable Unit No. 1
Millington, New Jersey

(mg/kg)

Chemical	TBCs														
	Federal SQC	TELs	LELs	SQBs	New York Sediment Criteria	ER-Ls	USEPA Region III Surface Soil Industrial RBC (b)			USEPA Region III Surface Soil Residential RBC (c)				Site Characterization/ Prioritization	
	USEPA 1993b	Smith et al. 1996	OMEE 1993	USEPA 1996b	NYSDEC 1999	Long & Morgan 1990/Long et al. 1995	Non-carcinogen	Carcinogen $1x10^{-6}$	Carcinogen $1x10^{-4}$	Non-carcinogen	Carcinogen $1x10^{-6}$	Carcinogen $1x10^{-4}$	C/N	LOC (d)	LOC Chosen
Asbestos	---	---	---	---	---	---	---	---	---	---	---	---	-	---	---

ARAR = Applicable or Relevant and Appropriate Requirement
C/N = Carcinogenic or noncarcinogenic according to USEPA (2000).
ER-L = Effect Range-Low
LEL = Lowest Effect Level
LOC = Level of Concern
RBC = Risk Based Concentration
SQB = Sediment Quality Benchmarks
SQC = Sediment Quality Criteria
TBC = To Be Considered
TEL = Threshold Effect Level
--- = No value available.
(b) USEPA (2000) Industrial exposures are based on 250 days/year.
(c) USEPA (2000) Residential exposures are based on 350 days/year. Residential values are presented for informational purposes only.
(d) The selection order for sediment is as follows: 1) the lower of the TEL and OMEE LEL; 2) in the absence of TELs and LELs, USEPA SQCs and then USEPA SQBs; 3) NY Sediment Criteria; 4) ER-Ls; 5) Region III Industrial (10^{-6}) RBCs.

Table 3-1
Sampling Media and Locations
Asbestos Dump Superfund Site
Millington, New Jersey

Sampling Media	Sampling Location
Groundwater	MW901
	MW902
	MW903
	MW904
	MW905
	MW906
	MW907
Surface Water and Sediments	SW-1/SD-1
	SW-2/SD-2
	SW-3/SD-3
	SW-4/SD-4
	SW-5/SD-5

Table 3-2
Proposed Sampling Frequency for Years 1 through 30
Millington Asbestos Dump Superfund Site

Analyte	Year 2	Year 3-9	Year 10	Year 11-19	Year 20	Year 21-29	Year 30
Asbestos	Biannual	TBD	TBD	TBD	TBD	TBD	TBD

Analysis will be conducted on Groundwater, Surface Water, and Sediments

TBD – Sampling frequency will be established based on the second year sampling results.

Table 3-3
Project Sampling and Analysis Strategy for Operable Unit 1

Asbestos Dump Superfund Site
Millington, New Jersey

GROUNDWATER	**Record Samples**	**QA Split Samples**	**Field Duplicates**	**Field Blanks**	**Rinsate Blanks**	**Trip Blanks**
ASBESTOS [1]	7	1	1	1	1	1
SURFACE WATER	**Record Samples**	**QA Split Samples**	**Field Duplicates**	**Field Blanks**	**Rinsate Blanks**	**Trip Blanks**
ASBESTOS [1]	5	1	1	1	1	0
SEDIMENTS	**Record Samples**	**QA Split Samples**	**Field Duplicates**	**Field Blanks**	**Rinsate Blanks**	**Trip Blanks**
ASBESTOS [2]	5	1	1	1	1	0

[1]Asbestos Fibers in Water, USEPA Test Method 100.2
[2]US EPA Test Method for the Determination of Asbestos in Bulk Building materials or Sediments, (Chatfield Method) EPA/600/R-93-116, July 1993

QA Split Samples and Field Duplicates frequency is based on rate of 10% per media sampled.
Field Blanks and Rinsate Blanks frequency is based on one per media sampled per sampling event.
Trip Blanks frequency is based on one per sampling event.

Table 4-1
Field Equipment for Groundwater Sampling

Sampling Equipment:	**Shipping Supplies:**
Horiba Model U-22 Multipurpose Probe	Coolers/Sample Shuttles
Electronic Interface Probe	Trash Bags
pH, temperature and conductivity meter	Foam Packaging Material
Positive displacement ground water sampling	Packaging Tape
pump (centrifugal, bladder or Peristaltic pump)	Zip-Loc™ Bags
Glass Jan (1 Liter)	
Plastic Sheeting	**Preservatives:**
Field Logbook	Ice
Plastic Bags	Reusable Cold Packs
Paper Towels/Handi-wipes	
Laboratory-cleaned Sample Containers	**Decontamination Material:**
Sample Labels	Plastic Buckets, 5-gallon
Label Tape	Laboratory Surfactant (Alconox)
Indelible Ink Pens	Distilled/Deionized Water
Six-Foot Ruler	Scrub Brushes
	Spray Bottles
Health and Safety Equipment:	Decontamination Tubs
HNu/OVM	Plastic Sheeting
PVC Steel-toed Boots	
Tyvek Suits	**Miscellaneous:**
Inner/Outer Gloves	Sample Collection Field Sheets
Safety Glasses	Analysis Request and Chain of Custody form
Hard Hats (if required)	Custody Seals
First Aid Kit	Shipping Labels

Table 4-2
Container Requirements for Groundwater Samples

Analytical Group	Container	Minimum Sample Size	Preservative	Holding Time
Asbestos	1 Liter Plastic	1 Liter	Ice at 4°C	48 Hours

Table 4-3
Field Equipment for Surface Water Sampling

Sampling Equipment: Laboratory-cleaned Sample Containers Beakers Paper Towels Sample Labels Label Tape Indelible Ink Pens Bottle Sampler Attached to PVC or Telescoping Aluminum Rod [a] **Health and Safety Equipment**: PVC Steel-toed Boots Tyvek® Suits Inner/Outer Gloves Safety Glasses Hard Hats (if required) First Aid Kit	**Shipping Supplies:** Coolers/Sample Shuttles Trash Bags Foam Packaging Material Packaging Tape Zip-Loc® Bags **Preservatives:** Ice Reusable Cold Packs **Decontamination Material:** Plastic Buckets, 5-gallon Laboratory Surfactant (Alconox) Distilled/Deionized Water Methanol (analytical grade) Scrub Brushes Spray Bottles Decontamination Tubs Plastic Sheeting **Miscellaneous:** Sample Collection Field Sheets Analysis Request and Chain of Custody form Custody Seals Shipping Labels

a = Unique to surface water, wastewater, catch basin fluids, and decontamination fluids

Table 4-4
Container Requirements for Surface Water Samples

Analytical Group	Container	Minimum Sample Size	Preservative	Holding Time
Asbestos	1-1 Liter Plastic	1 Liter	Ice at 4°C	48 Hours

Table 4-5
Field Equipment for Sediment Sampling

Sampling Equipment: Scoop or Trowel Laboratory-cleaned Sample Containers Beakers Paper Towels Sample Labels Label Tape Indelible Ink Pens **Health and Safety Equipment**: PVC Steel-toed Boots Tyvek® Suits Inner/Outer Gloves Safety Glasses Hard Hats (if required) First Aid Kit	**Shipping Supplies:** Coolers/Sample Shuttles Trash Bags Foam Packaging Material Packaging Tape Zip-Loc® Bags **Preservatives:** Ice Reusable Cold Packs **Decontamination Material:** Plastic Buckets, 5-gallon Laboratory Surfactant (Alconox) Distilled/Deionized Water Methanol (analytical grade) Scrub Brushes Spray Bottles Decontamination Tubs Plastic Sheeting **Miscellaneous:** Sample Collection Field Sheets Analysis Request and Chain of Custody form Custody Seals Shipping Labels

Table 4-6
Container Requirements for Sediment Samples

Analytical Group	Container	Minimum Sample Size	Preservative	Holding Time
Asbestos	8 oz. Glass	8 oz.	None	None

Table 5-1
Field Logs for Activities and Sample Types

Field Log	Activity or Sample Type	SAP Figure Number
Sample Collection Field Sheet	Groundwater, surface water, and sediment samples	4-1

Table 12-1
Calibration/Maintenance Schedule for Field Instruments

Instrument	Maintenance Procedure / Schedule
pH, Temperature and Conductivity Meter	Calibration conducted daily, see Manufacturer Instruction

Table 12-2
Field Instrument Uses, Detection Limits, and Calibration

Instruments	Uses	Detection Limits	Calibration	Comments
pH, Temperature and Conductivity Meter	See Manufacturer Instruction	NA	Perform daily, prior to the start of work, and at the end of the day according to manufacturer's instructions	None

Figures

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY	APPROVED BY	DRAWING NUMBER
---	---	SOM	J. Danza	3/30/00			706556-A5

780601a5.dwg 04/07/00 2:58pm J.R.D.

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Figure 1

Asbestos Dump Site OU-1

IMAGE	X-REF	OFFICE	DRAWING NUMBER
---	---	SOM	780601-D4

N

PASSAIC

RIVER

PIPE AND RIPRAP DRAIN SEE DWG C111 (TYP)

PVC PIPE DRAIN GRATE EL 227'-10"

SEE PARTIAL PLAN DWG C109

STANDPIPE INLET GRATE EL 227.0

RETAINING WALL

MW905

MW907

MW902

MW903

MW904

6' HIGH CHAIN LINK FENCE TO REMAIN SEE DWG C102 (TYP)

SLOPE

GRASSED LINED DITCH

INV 250.5

INV 249.5

INV 249.0

INV 248.5

STONE HOUSE

15" RCP

RIPRAP DITCH

2.0'

RELOCATED TYPE II DOUBLE SWING GATE

FINAL PLANTING LOCATION SEE PLANT SCHEDULE DWG C109 (TYP)

RELOCATED 6' HIGH CHAIN LINK FENCE

GRAVEL AREA TO REMAIN

MW906

6' HIGH CHAIN LINK FENCE TO REMAIN SEE DWG C102 (TYP)

24' TYPE I DOUBLE SWING GATE

ROAD

PAVED PARKING

BUILDING 4

BUILDING 2

VERIFY SCALE 0 1"

SCALE 0 30 60 90

LEGEND

240	EXISTING SUBGRADE ELEVATION SEE DWG C103
250	FINISH GRADE ELEVATION (ESTIMATED) SEE NOTE 1 DWG C107
x INV 249.0	INVERT ELEVATION OF GRASS DITCH
	GRAVEL SURFACE
	CRUSHED STONE SURFACE
	CHAIN-LINK FENCE
MW906 ⊕	MONITORING WELL

SOURCE;

BURNS & ROE INDUSTRIAL SERVICES CO. DRAWING No. c105, DATED 10/31/97, TITLED 'FINAL GRADING AND FENCE LOCATION PLAN'.

REV	DATE	BY	CHK'D	APR'VD	DESCRIPTION/ISSUE

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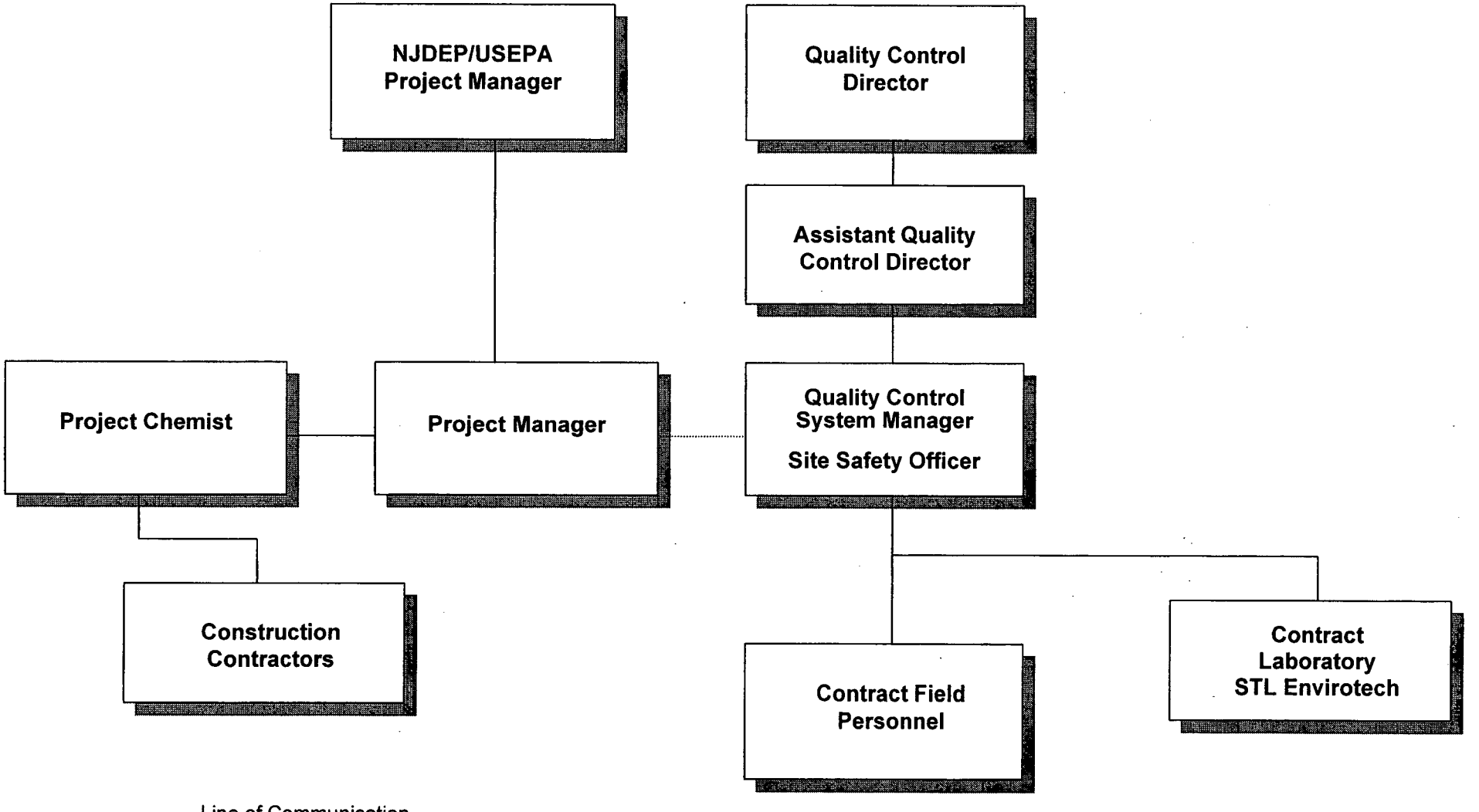
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
TRENTON, NEW JERSEY

FIGURE 1-1
SITE LAYOUT DRAWING
ASBESTOS DUMP SITE
MILLINGTON, NEW JERSEY

DESIGNED BY	D. AMBROSE	3/30/00	CHECKED BY		
DRAWN BY	J. DANZA	3/30/00	APPROVED BY		
SCALE: 1"=30'	DRAWING NO. 780601-D5		SHEET NO.		REVISION NO.

780601D4.dwg 01/15/01 10:14am J.R.D.

Figure 2-1
Project Organization Chart



INTERNATIONAL TECHNOLOGY CORPORATION

DATE	
TIME	
PAGE ____ OF ____	
PAGE	
PROJECT NO.	

SAMPLE COLLECTION LOG

PROJECT NAME _____

SAMPLE NO. _____

SAMPLE LOCATION _____

SAMPLE TYPE _____

COMPOSITE _____ YES _____ NO

COMPOSITE TYPE _____

DEPTH OF SAMPLE _____

WEATHER _____

CONTAINERS USED	AMOUNT COLLECTED

COMMENTS:

PREPARED BY: _____

COMMENTS: (Continued)

DATE	
TIME	
PAGE ____ OF ____	
PAGE	
PROJECT NO.	

PREPARED BY: _____

LEGEND

1. A SAMPLE COLLECTION LOG IS TO BE COMPLETED FOR EACH SAMPLE.
2. ALWAYS COMPLETE BOTH SIDES. IF SECOND SIDE IS NOT USED, DRAW A LINE THROUGH IT AND MARK N/A. FILL IN CONTROL BLOCK AND PREPARED BY.
3. ALL ENTRIES ON LOG ARE TO BE COMPLETED, IF NOT APPLICABLE MARK N/A.
4. DATE: USE MONTH/DAY/YEAR; I.E., 10/30/85
5. TIME: USE 24-HOUR CLOCK; I.E., 1835 FOR 6:35 P.M.
6. PAGE: EACH SAMPLE TEAM SHOULD NUMBER PAGE _____ OF _____ FOR THE DAY'S ACTIVITIES FOR ALL SHEETS PREPARED ON A SINGLE DAY, I.E., IF THERE ARE A TOTAL OF 24 PAGES (INCLUDING FRONT AND BACK) NUMBER 1 OF 24, 2 OF 24, ETC.
7. SAMPLE LOCATION: USE BORING OR MONITORING WELL NUMBER, GRID LOCATION (TRANSECT), SAMPLING STATION I.D., OR COORDINATE TO PHYSICAL FEATURES WITH DISTANCES. INCLUDE SKETCH IN COMMENT SECTION IF NECESSARY.
8. SAMPLE TYPE: USE THE FOLLOWING - SOIL; WATER (SURFACE OR GROUND); AIR (FILTERS, TUBES, AMBIENT, PERSONNEL); SLUDGE; DRUM CONTENTS; OIL; VEGETATION; WIPE; SEDIMENT.
9. COMPOSITE TYPE: I.E., 24-HOUR, LIST SAMPLE NUMBERS IN COMPOSITE, SPATIAL COMPOSITE.
10. DEPTH OF SAMPLE: GIVE UNITS, WRITE OUT UNITS SUCH AS INCHES, FEET. DON'T USE ' OR ".
11. WEATHER: APPROXIMATE TEMPERATURE, SUN AND MOISTURE CONDITIONS.
12. CONTAINERS USED: LIST EACH CONTAINER TYPE AS NUMBER, VOLUME, MATERIAL (E.G., 2 - IL GLASS; 4 - 40 ML GLASS VIAL; 1 - 400 ML PLASTIC; 1 - 3 INCH STEEL TUBE; 1 - 8 OZ. GLASS JAR).
13. AMOUNT COLLECTED: VOLUME IN CONTAINERS (E.G. 1/2 FULL).

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ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document No. 569301
Page 1 of ____

Project Name/No. [1] _____
Sample Team Members [2] _____
Profit Center No. [3] _____
Project Manager [4] _____
Purchase Order No. [6] _____
Required Report Date [11] _____

Samples Shipment Date [7] _____
Lab Destination [8] _____
Lab Contact [9] _____
Project Contact/Phone [12] _____
Carrier/Waybill No. [13] _____

Bill to: [5] _____
Report to: [10] _____

ONE CONTAINER PER LINE

Sample Number [14]	Sample Description/Type [15]	Date/Time Collected [16]	Container Type [17]	Sample Volume [18]	Pre-servative [19]	Requested Testing Program [20]	Condition on Receipt [21]	Disposal Record No. [22]
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	

Special Instructions: [23]

Possible Hazard Identification: [24]
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal: [25]
Return to Client ☐ Disposal by Lab ☐ Archive _____ (mos.)

Turnaround Time Required: [26]
Normal ☐ Rush ☐

QC Level: [27]
I. ☐ II. ☐ III. ☐ Project Specific (specify): _____

1. Relinquished by [28] (Signature/Affiliation)	Date: Time:	1. Received by [28] (Signature/Affiliation)	Date: Time:
2. Relinquished by (Signature/Affiliation)	Date: Time:	2. Received by (Signature/Affiliation)	Date: Time:
3. Relinquished by (Signature/Affiliation)	Date: Time:	3. Received by (Signature/Affiliation)	Date: Time:

Comments: [29]

White: To accompany samples
Yellow: Field copy
*See back of form for special instructions.

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ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD (cont.)*

Reference Document No.[30] _____
Page___of ____

Project Name _____ Project No. _____ Samples Shipment Date _____

ONE CONTAINER PER LINE

Sample[14] Number	Sample[15] Description/Type	Date/Time[16] Collected	Container[17] Type	Sample[18] Volume	Pre-[19] servative	Requested Testing[20] Program	Condition on[21] Receipt	Disposal[22] Record No.
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	

White: To accompany samples Yellow: Field copy

*See back of form for special instructions.

MCA 3/15/91

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FIELD ACTIVITY DAILY LOG

DAILY LOG				
	DATE			
	NO.			
	SHEET		OF	

PROJECT NAME:	PROJECT NO.:
FIELD ACTIVITY SUBJECT:	
DESCRIPTION OF DAILY ACTIVITIES AND EVENTS:	
VISITORS ON SITE:	CHANGES FROM PLANS AND SPECIFICATIONS, AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS:
WEATHER CONDITIONS:	IMPORTANT TELEPHONE CALLS:
IT PERSONNEL ON SITE:	
SIGNATURE:	DATE:

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NONCONFORMANCE REPORT

NCR Number:	Project Name: Project Number:	Date:	Page____of____

Nonconformance Description (include specific requirement violated):

Identified By: _____ Date: _____

Root Cause of Nonconforming Conditions:

Corrective Action to be Taken (include date when action(s) will be completed):

To be Performed By: _____ Anticipated Completion Date: _____

Action to be Taken to Preclude Recurrence:

To be Performed By: _____ Anticipated Completion Date: _____

Acceptance By: _____ Date: _____ Acceptance By: _____ Date: _____
Project Manager QA Officer

Corrective Actions Completed By and Date:	**Verification Completed By and Date:**

Figure 10-1

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FIELD WORK VARIANCE

VARIANCE NO. _____

PROJECT NO. PAGE _____ OF _____

PROJECT NAME: DATE _____

CONTRACT NO. TASK ORDER NO.

VARIANCE (INCLUDE JUSTIFICATION)
(INCLUDE PRESENT REQUIREMENTS) REQUESTED BY: _____

PROPOSED CHANGE

TECHNICAL JUSTIFICATION

COST / SCHEDULE IMPACT

REASON FOR CHANGE _____ ADDITION _____ DELETION

CHANGE ORDER REQUIRED _____ NO _____ YES CHANGE ORDER NO. _____

APPLICABLE DOCUMENT

CC:

APPROVED BY _____ DATE _____
PROJECT MANAGER

APPROVED BY _____ DATE _____
QUALITY CONTROL SYSTEM MANAGER

APPROVED BY _____ DATE _____
CONTRACTING OFFICER'S REPRESENTATIVE

Figure 10-2

Appendix A
Standard Operating Procedures

CHAIN OF CUSTODY

STANDARD OPERATING PROCEDURE

1.0 Purpose

This Standard Operating Procedure (SOP) establishes the method and responsibilities associated with the maintenance and custody of samples which are to be used to provide data which form a basis for making project related decisions. It outlines the general procedures for maintaining and documenting sample chain of custody from the time of sample collection through sample disposition.

2.0 References

2.1 JT, 1999, Quality Control Plan, Sunflower Army Ammunition Plant (QCP)

3.0 Definitions

3.1 Chain of Custody

The Chain of Custody (COC) document is the written record that traces the sample possession from the time each sample is collected until its final disposition, sometimes called the "cradle to grave" record. Chain of Custody is maintained by compliance with one of the following criteria:

- The sample is in the individual's physical possession
- The sample is maintained in the individual's physical view after being in his/her possession
- The sample is transferred to a designated secure area restricted to authorized personnel
- The sample is sealed and maintained under lock and key to prevent tampering, after having been in physical possession.

3.2 Waybill

A document that contains a list of the goods and shipping instructions relative to a shipment.

3.3 Common Carrier

For the purpose of this procedure, the common carrier is any commercial carrier utilized for the transportation of the sample(s) from the field to the laboratory.

4.0 Procedure

4.1 Responsibilities

4.1.1 The Project Manager is responsible for assuring proper COC is initiated at the time the sample(s) are collected and maintained throughout the handling and subsequent transportation of the sample(s) to the designated laboratory. Additionally, he/she is the project authority for determining the disposition and fate of sample(s) which have identified deficiencies (e.g., missed holding times, elevated temperature at receipt, etc.).

4.1.2 The sample team member(s) are responsible for properly documenting and maintaining the COC from the time of sample collection until the sample is delivered to the lab.

4.1.3 Laboratory personnel are responsible for receipt and entry of samples into the laboratory which have been submitted under a COC document. Additionally, samples received will be entered into the laboratory COC procedures by properly documenting and maintaining COC from the moment that they take custody of the sample at the laboratory until the sample is disposed of or returned to the client.

4.2 General

4.2.1 An overriding consideration for data resulting from laboratory analyses is the ability to demonstrate that the samples were obtained from the locations stated and that they reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal must be documented to accomplish this. Documentation will be accomplished through a COC Record that lists each sample and the individuals performing the sample collection, shipment, and receipt.

4.2.2 The IT COC document is a preprinted form with a unique six-digit control number in the upper right-hand corner. The white copy will accompany the samples while the yellow field copy will be retained in the project file.

4.3 Field Sample Custody

4.3.1 Sampling personnel, upon collection of samples for analysis, will properly complete a COC Record form (Form 5-1a / 5.1b). The COC document will be the controlling document to assure that sample maintenance and custody are maintained thereby assuring the sample(s) are representative of the environment from which they were collected. At a minimum, the following information will be recorded on the COC document:

- The unique identification number assigned to each sample.
- A brief description of the sampling location and a physical description of the sample type.
- The date and time of the sample collection.
- Container type (e.g., glass, poly, brass sleeve, etc.).
- Sample volume and number of containers (e.g., 2 x 40 ml, 3 x 1 liter).
- Sample preservation (e.g., HNO_3, H_2SO_4, 4°C).
- Requested analyses.
- Special instructions to the laboratory including handling requirements, quality assurance/quality control, health and safety, and sample disposition.
- The project name and number.
- The date the analytical report is due.
- The names of all sampling personnel.
- The name and phone number of the project contact.
- The name and phone number of the laboratory contact.
- The name of the courier and the waybill number (if applicable).
- A unique document reference number.

4.3.2 The COC document will be initiated in the field by the person collecting the sample and signed by each individual who has the samples in their possession. Each time that sample custody is transferred, the former custodian must sign over the COC as Relinquished

By, and the new custodian must sign on to the COC as Received By. Each signature must be accompanied by the date, time, and the name of their project or company affiliation.

4.3.3 Transferring of COC from sampling personnel to the analytical laboratory will be performed in accordance with the requirements stated below.

4.3.3.1 If the sampling personnel deliver the samples to the laboratory, transfer of COC occurs as follows:

- The sample collector delivers the samples to the laboratory and relinquishes the sample directly to a laboratory representative.
- The collector signs the COC listing his/her name, affiliation, the date, and time. Any person involved in the collection of the sample may act as the sample custodian.
- The laboratory representative must receive the samples by signing his/her name, affiliation, the date, and time on the COC. The laboratory representative may decline to take receipt of the samples if the COC is not properly completed or if the samples are not properly packaged. All designated laboratory personnel may act as the sample custodian.
- One copy of the COC is given to the sample collector to be returned to the project files and one copy is maintained with the samples at the laboratory.

4.3.3.2 If the sampling personnel transfer sample(s) to the laboratory utilizing a common carrier, sampling personnel will retain COC responsibility and the common carrier is not responsible for maintaining sample custody. The sample collectors are responsible for packaging the samples in a manner that meets the COC definition criteria, that is, the samples are sealed to prevent tampering. When transferring samples to the courier for transport, COC procedures are maintained as follows:

- The sample collector lists the courier affiliation and waybill number on the COC.
- The sample collector relinquishes custody by signing his name, affiliation, date, and time. The collector keeps a copy of the relinquished COC for the project file.
- The relinquished original COC is sealed in a watertight plastic bag and taped to the inside of the lid of the container used for transportation.
- The transportation container is sealed to prevent tampering and given to the courier for delivery to the laboratory.

- The sample collector obtains a copy of the waybill from the courier for the project file.

- The laboratory representative must receive the samples by signing his/her name, affiliation, the date, and time on the COC. This copy is maintained with the samples at the laboratory.

- The laboratory representative obtains a copy of the waybill from the courier for the project file.

4.4 Analytical Laboratory Custody

4.4.1 Upon receipt at the analytical laboratory, the field generated COC document will be signed, dated, time marked, temperature marked, and laboratory identification will be provided in the appropriate spaces.

4.4.2 Laboratory receipt personnel will enter the samples into the laboratory by implementing the sample custody procedures addressed within their IT approved QA Program.

4.4.3 After completion of analytical testing, sample remnants not consumed during testing may be kept for six months beyond the completion of analysis, unless otherwise specified by a notation on the COC that samples are to be returned to the project site for disposal. Once this time period has elapsed, the samples will be disposed of and the disposal record number will be recorded on the laboratory record copy of the COC.

5.0 Records

5.1 Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files in accordance with Section 4.0 of the Sunflower AAP QCP.

6.0 Figures/Forms

6.1 Chain of Custody Record Form (Figure 5-1a / 5-1b).

SAMPLE HANDLING, PACKAGING AND SHIPPING

STANDARD OPERATING PROCEDURE

1.0 Purpose

This Standard Operating Procedure (SOP) outlines the methods and responsibilities for field personnel to use in the packaging and shipping of environmental samples for chemical and physical analysis. This SOP only applies to the packaging and shipping of limited quantity, low concentration environmental samples. This procedure does not apply to those samples considered hazardous materials, hazardous waste, mixed waste, radioactive waste, and/or dangerous goods. Those requirements are specified in the Department of Transportation (DOT) 49 CFR 114-327 and the International Air Transport Association (IATA) procedures. The details within this SOP are only applicable to the general requirements for sample packaging and shipping and should only be used as a guide for developing more job-specific work plans.

2.0 References

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidelines for Conducting Remedial Investigation and Feasibility Studies under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.3 Code of Federal Regulations, DOT 49 CFR parts 100 to 177, Revised October 1, 1992.

2.4 Dangerous Goods Regulations, IATA, January 1, 1994.

2.5 IT, 1999, Contractor Quality Control Plan, Sunflower Army Ammunition Plant (QCP).

3.0 Definitions

3.1 Environmental Sample

A limited quantity, low concentration sample that does not require DOT or IATA hazardous waste labeling as a hazardous waste or material.

3.2 Hazardous Waste Sample

Medium or high concentration sample requiring either DOT or IATA labeling as a hazardous waste or material.

3.3 Hazardous Waste

Any substance listed in 40 CFR Subpart D (260.30 et seq.) or otherwise characterized as ignitable, corrosive, reactive, or toxic as specified in Subpart C (261.20 et seq.) that would be subject to manifest and packaging requirements specified in 40 CFR 262. Hazardous waste is defined and regulated by the U.S. Environmental Protection Agency (USEPA).

3.4 Hazardous Material

A substance or material in a quantity or form which may pose an unreasonable risk to health, safety, and/or property when transported in commerce. Hazardous material is defined and regulated by DOT (49 CFR 173.2 and 172.101) and IATA (Section 4.2).

3.5 Sample

Physical evidence collected from a facility or the environment which is representative of conditions at the point and time at which the sample is collected.

4.0 Procedure

4.1 Responsibilities

4.1.1 Compliance with this procedure is the responsibility of project management, site management, health and safety, and field personnel.

4.1.2 Project Manager - is responsible for the development and review of site-specific work plans which address the specific sample handling, packaging, and shipping requirements for the project. Review the project specific documentation forms to ensure they are appropriate for the field activities. The Project Manager is also responsible for seeing that field personnel receive proper training and maintain quality assurance/quality control (QA/QC).

4.1.3 Contractor Quality Control Manager(CQCM) - is responsible for observing field activities and the periodic review of documentation generated during sample handling, packaging, and shipping and the periodic review and audit of field personnel as they perform the work.

If problems arise, the CQCM is also responsible for swift implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to requirements, issuing nonconformances).

4.2 Sample Handling

4.2.1 Inspect the sampling containers (obtained from the analytical laboratory prior to the sampling event) to ensure that they are appropriate for the samples being collected, correctly preserved, and undamaged.

4.2.2 When collecting a sample always use approved/site specific personal protective equipment (e.g., gloves, etc.) to prevent cross-contamination from sample to sample but also as a health and safety requirement.

4.3 Field Packaging

4.3.1 Collect the samples in accordance with the site-specific work plans and applicable SOPs.

4.3.2 As soon as possible after sample collection, tightly seal the container, and place a piece of custody tape over or around the cap. The custody tape should be placed over the cap so that any attempt to remove the cap will cause the tape to be broken. Do not place custody tape over a volatile organic analysis (VOA) vial septum.

4.3.3 Place all containers in separate, appropriately sized, airtight, seam sealing polyethylene bags (e.g., Ziploc™). Seal the bag, removing any excess air.

4.3.4 Place the bagged container inside an insulating shipping container, "cooler." This cooler should have frozen blue ice inside to assure samples remain cool, "4°," during transit from field to the packaging location.

4.3.5 Because blue ice does not maintain the 4°C standard required for sample shipping, it should only be used while in the field collecting samples.

4.3.6 Maintain the samples under chain of custody (COC) (Form 5.1a / 5.1b) in accordance with the site-specific work plans and appropriate SOPs.

4.4 Sample Packaging

4.4.1 Inspect the integrity of the shipping container. The container is generally a "cooler" constructed of heavy plastic or metal with appropriate insulating properties so that variations in temperature during shipping are minimized. Also make sure that the drain plug has been sealed with nylon reinforced strapping tape or mailing tape.

4.4.2 Place two to four inches of absorbent packaging material (e.g., Vermiculite™) in the bottom of the shipping container.

4.4.3 Carefully check the COC record against the collected sample labels and containers to ensure that the sample numbers, sample description, date and time of collection, container type and volume, preservative, and the required analytical methods are correct and in agreement.

4.4.4 Place the samples in the shipping container, allowing sufficient room between the samples to place ice and/or packing material.

4.4.5 Double bag and seal crushed or cubed ice in heavy-duty polyethylene bags. Place these bags of ice on top of and between samples. Blue ice should not be used for sample shipping; it does not maintain the 4°C temperature necessary for regulatory compliance. Include a VOA vial of tap water clearly labeled "temperature check" so that the laboratory can verify the temperature of the samples upon receipt. The remaining space will be filled with packing material.

4.4.6 All samples requiring temperature preservation stated at 4°C will be acceptable "as in" within the range of 2°C to 6°C. The laboratory should record the temperature of receipt upon the COC. For all samples received above 6°C to 10°C, the sample(s) and temperature (in 1°C increments) will be noted on the COC and then analyzed. For samples with temperatures greater than 10°C, the samples will be rejected by the laboratory for analysis

and immediately reported to the Project Manager. For VOA samples below 0°C, the samples will be indicated as such to the project manager or their designee and analyzed and also reported.

4.5 Sample Shipping

4.5.1 The person in charge of sample custody will time, date, and sign over relinquishment of custody on the COC. When a common carrier is to be used for sample shipment, also record the air/waybill number (tracking number) and the name of the carrier on the COC record. Place the original copy of the COC record in a sealed, clear plastic envelop or bag and tape the COC record envelope to the inside lid of the shipping container. Retain a copy of the COC record for tracking purposes.

4.5.2 Using nylon reinforced strapping tape or mailing tape, seal the shipping container.

4.5.3 Place custody tape over opposite ends of the lid.

4.5.4 Mark the container "THIS END UP," or apply arrow labels that indicate the proper position to be maintained during shipping.

4.5.5 Apply a label stating the name and address of the shipper and the receiving laboratory on the outside of the cooler.

4.5.6 Turn the sample over to the courier or carrier for delivery to the laboratory. All samples should be shipped by the fastest available method to the laboratory as soon as possible after sample collection.

NOTE: The courier or carrier is not responsible for sample custody and is not required to sign the COC.

4.5.7 Contact the appropriate laboratory personnel to advise them of the sample shipment.

4.5.8 Review the COC and sample collection forms for completeness and turn them over to site or project management.

5.0 Records

5.1 Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files and in accordance with Section 4.0 of the Sunflower AAP QCP.

6.0 Figures / Forms

6.1 Analysis Request and Chain of Custody Record, Form 5-1a / 5.1b.

SAMPLE LABELING

STANDARD OPERATING PROCEDURE

1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for sample labeling. Sample labeling is required to identify, track and trace samples from the time of collection until the time of disposal. Additional specific procedures and requirements will be provided in the project work plans.

2.0 References

2.1 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.2 IT, 1999, Contractor Quality Control Plan, Sunflower Army Ammunition Plant (QCP)

3.0 Definitions

3.1 Sample Label

Sample labels include all forms of sample identification (labels or tags) that are physically attached to samples collected and provide, at a minimum, the information required by this SOP and project work plans.

4.0 Procedure

This section contains both the responsibilities and procedures involved with sample labeling. Sample labeling is required to identify, track and trace samples from the time of collection until the time of disposal. The details within this SOP should be used in conjunction with the project work plans. The project work plans will commonly provide the following information:

- Sample collection objectives
- Numbers, types and locations of samples to be collected
- Any additional sample labeling requirements or procedures beyond those covered in this SOP, as necessary.

4.1 Responsibilities

4.1.1 The Project Manager is responsible for ensuring that all sample collection and labeling activities are conducted and documented in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic observation of field activities and review of field generated documentation associated with this sample labeling SOP. The CQCM is also responsible for the implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to sample labeling requirements, issuing nonconformances, etc.) if problems occur.

4.1.3 Field personnel assigned to sampling and sample labeling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from the procedures to the Site Superintendent, Project Manager, or the CQCM.

4.2 Sample Labeling

4.2.1 Document all the information necessary on the sample label and ensure that the label is physically attached to each respective sample. Each sample label must contain at a minimum the following information:

- Project name
- Project number
- Date and time of collection
- Sample location
- Sample identification number
- Collector's name
- Preservative used (if any).

Additional information may also be required per the project work plans and must accordingly be included on all sample labels.

4.2.2 Indelible ink should be used in filling out all sample labels.

4.2.3 Ensure that each sample collected has a sample label.

4.2.4 Ensure that the information documented on the sample label corresponds with the information documented on the Soil or Water Sample Collection Field Sheet (Figure 4-3 or Figure 4-6) and Analysis Request and Chain-of-Custody Record (Figure 5-1a/b).

5.0 Records

5.1 Records generated as a result of implementation of this SOP will be controlled and maintained in the project record file in accordance with Section 4.0 of the SFAAP QCP.

6.0 Figures / Forms

6.1 Analysis Request and Chain-of-Custody Record (Figure 5-1 a/b)

SAMPLE NUMBERING

STANDARD OPERATING PROCEDURE

1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for sample numbering. Sample numbering is required to identify, track and trace samples from the time of collection until the time of disposal. Additional specific procedures and requirements will be provided in the project work plans.

2.0 References

2.1 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.2 SOP 17.1 - Sample Labeling

2.3 IT, 1999, Quality Control Plan, Sunflower Army Ammunition Plant (QCP)

3.0 Definitions

3.1 Sample Number

A sample number is a unique alphanumeric identification assigned to each and all physical samples collected as part of any given project.

4.0 Procedure

This section contains both the responsibilities and procedures involved with sample numbering. Sample numbering is required to provide a means by which samples can be identified, tracked and traced from the time of collection until the time of disposal. The details within this SOP should be used in conjunction with project work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Numbers, types, and locations of samples to be collected
- Project-specific character string to be used for the sample numbering
- Person responsible for issuing sample numbers to field personnel conducting sampling activities

- Any additional sample numbering requirements or procedures beyond those covered in this SOP, as necessary.

4.1 Responsibilities

4.1.1 The Project Manager is responsible for ensuring that all sample collection and numbering activities are conducted and documented in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic observation of field activities and review of field generated documentation associated with this SOP. The CQCM is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to sample numbering requirements, issuing nonconformances, etc.) if problems occur.

4.1.3 Field personnel assigned to sampling and sample numbering activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from the procedures to the Site Superintendent, Project Manager, or the CQCM.

4.2 Sample Numbering

4.2.1 The alphanumeric character string (AANNNN vs. AAANNNNN) will be determined on a project-specific basis and stated in the project work plans. The sample numbers should be as simple and preferably as short as possible; however, they should also be compatible with the laboratory analytical tracking system and the data management system to be used for the project sample data.

4.2.2 A unique sample number will be assigned in the field to each sample to be submitted for analysis.

4.2.3 The sample numbers will be assigned sequentially (e.g. SB-1000, SB-1001) as the samples are collected. Both environmental (soil, sediment, groundwater, air, etc.) and QC samples will be assigned sequential sample numbers with the same prefix so that the laboratory will be unable to distinguish between the QC and non-QC samples.

4.2.4 The sample number will be recorded, using indelible ink, directly on the sample label attached to each sample per SOP 17.1. Prenumbered tape may also be used and affixed to each sample; however, their use is not mandatory for this SOP. When used, the sample number on the preprinted tape must also be recorded on the sample label.

4.2.5 The sample number must also be recorded on a FADL and the Analysis Request and Chain-of-Custody Record (Figure 5-1a/b).

4.2.6 It is recommended that one person (either the Site Superintendent or other designee) be responsible for issuing sample numbers to field sampling personnel and ensuring that the sample sequence numbers are applied to samples in the sequence in which they are collected.

4.2.7 It is also recommended the field supervisor or designee be responsible for keeping a master sample log listing the sample numbers and a brief description of the samples collected.

5.0 Records

Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files in accordance with Section 4.0 of the SFAAP QCP.

6.0 Figures / Forms

6.1 Analysis Request and Chain of Custody Record (Figure 5-1 a/b)

FIELD QC SAMPLING

STANDARD OPERATING PROCEDURE

1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for conducting field quality control (QC) sampling. Field QC sampling is required to assist in verifying the quality and integrity of samples collected during a given sampling event. Additional specific field QC sampling procedures and requirements will be provided in the project work plans.

2.0 References

2.1 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.2 SOP 1.1 - Chain-of-Custody

2.3 SOP 2.1 - Sample Handling, Packaging and Shipping

2.4 SOP 9.1 - Groundwater Sampling

2.5 SOP 17.1 - Sample Labeling

2.6 SOP 17.2 - Sample Numbering

2.7 IT, 1999, Quality Control Plan, Sunflower Army Ammunition Plant (QCP)

3.0 Definitions

3.1 Field QC Sample

A field QC sample is a physical sample collected during or for a specific sampling event. The purpose of this sample is to evaluate the quality and integrity of original samples collected during the specific sampling event.

4.0 Procedure

This section contains both responsibilities and requirements for field QC sampling. Field QC sampling is required to provide data to verify the quality and integrity of environmental samples collected during a given sampling event.

The details within this SOP should be used in conjunction with project plans. These plans will generally provide the following information:

- Sample collection objectives
- Numbers, types and locations of environmental (non-QC) samples to be collected
- Numbers and types of supportive QC samples to be collected
- Any additional QC sampling requirements or procedures beyond those covered in this SOP, as necessary.

4.1 Responsibilities

4.1.1 The Delivery Order Project Manager is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic review of field generated documentation associated with this SOP. The CQCM is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

4.1.3 Field personnel assigned to environmental and QC sampling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Site Superintendent, Delivery Order Manager, or the CQCM.

4.2 Quality Control Sampling Requirements

4.2.1 Field QC samples may consist of different media. Typical QC samples are as follows:

- Equipment rinsate (ER)
- Field blank (FB)
- Field duplicate (FD)

4.2.1.1 Equipment rinsate samples are collected from the final rinse water during decontamination of groundwater, soil, or waste sampling equipment. This type of equipment includes bailers, splitspoon samplers, soil sample sleeves, hand augering equipment, surface soil sampling equipment, purge and sample pumps, etc.

Rinsate samples are generally collected at a rate of one per day per sampling team during the sampling event. Equipment rinsates are usually collected from dedicated sampling equipment only upon installation. The number or rate of equipment rinsate samples to be collected for a particular project will be specifically developed and documented in the project work plans. The specific chemical analyses to be conducted for the rinsate samples will also be developed and documented in the project work plans.

4.2.1.2 Field blanks are samples prepared by filling sample containers, at a sample location, with water which is used for decontamination. One sample from each sampling event and each water source or lot number is generally collected and analyzed for all parameters of interest for the project. Upon collection, a description of the water source for the field blank sample and the sample location should be documented on the FADL.

The number or rate of field blank samples to be collected for a particular project will be specifically developed and documented in the project work plans. The specific chemical analyses to be conducted for the field blank samples will also be developed and documented in the project work plans.

4.2.1.3 For soils, field duplicate samples are generally collected by co-located sampling (e.g., using successive sample tubes from the same split spoon sampling run) or by splitting samples. Field duplicate water samples are commonly collected by retaining consecutive samples from the sampling device (e.g., bailer or sample pump discharge line). Field duplicate water samples may also be generated by splitting a collected volume; however, this practice may lead to a loss in volatile organic compounds and is not acceptable practice for volatile analyses.

Field duplicate samples are commonly collected at a rate of 10 percent per media sampled. However, the number or rate of field duplicate samples to be collected for a particular project will be specifically developed and documented in the project work plans. The specific chemical analyses to be conducted for the field duplicates will also be developed and documented in the project work plans.

4.2.2 The type and number of QC samples collected for a particular project is based on specifications provided in project specific documents, i.e., the project work plans. Field QC samples are to be collected at appropriate times during a sampling event.

4.2.3 All field QC samples will be collected in proper containers with appropriate preservation in accordance with Table 4-2 or Table 4-5 of the LCAAP Global Field Sampling Plan (FSP) and the project work plans.

4.2.4 The collection of field QC samples consisting of various media (e.g., soil, groundwater, etc.) will follow procedures in sample collection SOPs for the respective media and any other applicable procedures in the project work plans. For example, the collection of a groundwater field duplicate QC sample will follow procedures specified in the groundwater sampling SOP (SOP 9.1). Equipment rinsate samples are collected directly while rinsing the sampling equipment following appropriate procedures in SOP 9.1 and the project work plans. Field blank samples are collected by pouring decontamination water directly into sample containers following appropriate protocol in SOP 9.1 and the project work plans.

4.2.5 Field QC samples will be labeled and numbered as described in SOPs 17.1 and 17.2 respectively and the project work plans.

4.2.6 The field QC samples will also be maintained under custody per SOP 1.1, and be appropriately stored, handled and shipped per SOPs 19.1 and 2.1, respectively.

5.0 Records

Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files in accordance with Section 4.0 of the SFAAP QCP.

6.0 Figures / Forms

ON-SITE SAMPLE STORAGE

STANDARD OPERATING PROCEDURE

1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for on-site sample storage. On-site sample storage may be required for samples collected during a given project. Additional on-site sample storage procedures and requirements will be provided in the project work plans.

2.0 References

2.1 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.2 SOP 1.1 - Chain of Custody

2.3 SOP 2.1 - Sample Handling, Packaging and Shipping

2.4 SOP 17.1 - Sample Labeling

2.5 SOP 17.2 - Sample Numbering

2.6 IT, 1999, Quality Control Plan, Sunflower Army Ammunition Plant (QCP)

3.0 Definitions

3.1 Field sample

A sample that has been collected at a project site, during the execution phase of the project, and for the purposes of the project, as defined in the project work plans.

3.2 On-site

For purposes of this SOP, "on-site" is defined as any area within the project site.

3.3 On-site sample storage

For purposes of this SOP, "on-site sample storage" applies to samples stored within the project site for a temporary period of time. Typically, samples may be stored on-site if they are in transit between the project site and a designated laboratory.

4.0 Procedure

This section contains both responsibilities and requirements pertaining to on-site sample storage. Proper storage is essential to maintain the quality and integrity of samples collected during a field project.

The details within this SOP should be used in conjunction with project work plans. At a minimum, The project work plans will provide the following information:

- Sample collection objectives
- Numbers, types and locations of samples to be collected
- Any additional on-site sample storage requirements or procedures beyond those covered in this SOP, as necessary.

4.1 Responsibilities

4.1.1 The Project Manager is responsible for ensuring that all on-site sample storage activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic observation of field activities and review of field generated documentation associated with this SOP. The CQCM is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to sample storage requirements, issuing nonconformance, etc.) if problems occur.

4.1.3 Field personnel assigned to sample storage activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Site Superintendent, Project Manager, or the CQCM.

4.2 On-Site Sample Storage Requirements

4.2.1 Samples of all types of media may required to be stored on-site. The manner in which these samples are stored will be appropriate for individual samples or each sample type.

4.2.2 Samples collected for chemical analysis are typically required to be stored at approximately 4° Centigrade (° C). Therefore, such samples should either be preserved using water ice, and/or in a "Sample-only" refrigerator until received by the assigned laboratory. Blue ice is not recommended for on-site sample storage, as it does not maintain the 4°C temperature necessary for regulatory compliance. If a refrigerator is used to store samples at the project site, this refrigerator will be dedicated for the sole use of samples; no food, drinks or other personal items will be allowed in this refrigerator. A calibrated thermometer will be placed in the refrigerator. The temperature in the refrigerator will be recorded on a log on a daily basis to document compliance with the 4° (+/- 2) Centigrade (° C) requirement.

4.2.3 Samples that do not require refrigeration (e.g. air samples and samples for geotechnical or radionuclide analysis) should be stored on-site in a designated, marked area. Recent changes in SW-846 guidelines only require samples for the determination of mercury and/or hexavalent chromium to be kept cool. Samples for all other metals determinations may be maintained under custody only, unless state or federal regulations require the cool environment.

4.2.4 Samples that are stored on-site must be stored in appropriate containers per the project-specific work plans and be maintained under custody per SOP No. 1.1.

4.2.5 Samples that are stored on-site must not be stored in a manner in which they may threaten the integrity of other samples in the holding location,

4.2.6 All samples that are stored on-site must be labeled per SOP No. 17.1, numbered per SOP 17.2, and appropriately handled per SOP No. 2.1.

4.2.7 It is recommended the Site Superintendent or other designee be responsible for maintaining a master sample log listing sample numbers and a brief description of samples collected. The master log should be reviewed on a daily basis for samples that are under storage on site. The samples should then be appropriately shipped, following procedures per SOP No. 2.1, to ensure that holding time are not missed.

4.2.8 Samples that are not shipped to the assigned laboratory should be disposed of in a timely manner following appropriate disposal practices for the media from which the samples were initially obtained.

5.0 Records

Records generated as a result of implementation of this SOP will be maintained in the Project Records file in accordance with Section 4.0 of the Global CQCP.

6.0 Figures / Forms

6.1 Refrigerator Temperature Log

DRUM/CONTAINER HANDLING

STANDARD OPERATING PROCEDURE

1.0 Purpose and Summary

The purpose of this procedure is to establish standard requirements for the handling of drums and similar containers. It describes the requirements for compliance under the OSHA hazardous waste operations rules and provides general guidance intended to be supplemented by site-specific information contained in project SHSP.

2.0 Table of Contents

3.0 Responsibility Matrix

3.1 Procedure Responsibility

The Program CIH is responsible for the issuance, revision, and maintenance of this procedure.

3.2 Action/Approval Responsibility

The Responsibility Matrix is Attachment 1.

4.0 Definitions

4.1 Remote Drum Handling System

Equipment suitable for grabbing, lifting, loading, or manipulating drums that does not require personnel to come in close physical contact with the drums.

5.0 Text

5.1 Preliminary Characterization

Prior to the initial handling of drums, as much information as possible will be obtained so that the hazards can be evaluated and preliminary controls instituted to protect drum inspection personnel. This preliminary information gathering activity will focus on identifying potential or suspected drum contents that may pose an immediate danger. Potential sources of this preliminary characterization information may include:

- Waste storage inventories and manifests or shipping papers
- Generator or transporter records
- Company records, receipts, log books, or ledgers
- Records from state and federal pollution control regulatory agencies, state attorney general's office, state occupational safety and health agencies, state fire marshal's office
- Interviews with previous employees and nearby residents
- Local fire and police department records
- Previous site investigations.

5.2 Drum Inspection

A visual inspection will be performed to assess the associated degree of hazard for each drum. This visual inspection, along with information gathered during the preliminary characterization, will be used to determine each drum's specific handling procedure. Personnel performing drum inspections should look for the following information and record the results on a Hazardous Waste Characterization form.

- Labels, symbols, words, or other markings that could indicate potential drum contents
- Signs of deterioration such as corrosion, rust, or leaks
- Drum type (polyethylene or PVC-lined drums, exotic metal drums, single-walled drums used as a pressure vessel, or laboratory packs)
- Drumhead configuration (whole lid removable, has a bung, or contains a liner).

Monitoring in the immediate drum vicinity will be conducted using a radiation survey instrument, photoionization detector, combustible gas meter, and other instrumentation as prescribed in the project SHSP. Drums that exhibit radiation levels above background will not be moved until a Certified Health Physicist has been contacted and provides guidance on how to proceed. Monitoring action levels and their respective response actions will be included in the project SHSP.

Upon completion of the preliminary characterization and visual inspection, each drum will be classified into one of the following six categories:

- Bulging - intact drum under pressure indicated by swelling or bulging
- Leaking/deteriorated - drum's integrity has been compromised and contains material which is or could leak if moved
- Empty/crushed - drums that were empty or crushed prior to discovery
- Laboratory packs - drums containing individual containers of laboratory materials normally surrounded by cushioning absorbent material
- Characterized - intact drum in good condition with known contents
- Shock sensitive - drums with markings that indicate explosive or highly reactive compounds or with crystalline formations present.

5.3 Drum Handling/Opening

The preliminary characterization and drum inspection procedures described in Sections 5.1 and 5.2 will be used to determine which of the following drum handling/opening processes will be implemented. It is important to note that these are only general guidelines which must be supplemented by the project SHSP.

5.3.1 Bulging Drums

- Bulging drums are extremely hazardous and should be handled with the utmost care. In no case will an uncharacterized bulging drum be moved by hand. A remote drum handling system (i.e., drum grappler, nylon yokes, etc.) used in conjunction with explosion-resistant shields will be employed when handling drums of this nature.

- Dependent upon job site conditions, drums will either be opened in place or moved to a staging area. The drum staging and opening areas should be physically separated to minimize the risk of a chain reaction in the event of fire or explosion during initial drum opening.

- Personnel in the drum opening area will be limited to the minimum necessary to perform the activity. If personnel must be in the immediate area, they will be protected by explosion-resistant shields for protection in the case of an accidental detonation. All required emergency equipment will also be placed behind this shield.

- Initial opening of drums will be done utilizing a spark-resistant spike on the arm of a backhoe or other remote device outfitted with appropriate explosion-resistant shielding. The spike will be used to slowly puncture the lid of the drum, allowing for access to its contents by sampling personnel.

- After this puncturing is complete, monitoring will be conducted using a radiation survey meter, photoionization detector, combustible gas indicator, and other instrumentation as prescribed in the project SHSP. Results will be compared to the action levels established in the SHSP, and applicable responses will be initiated.

- As monitoring results dictate, the drum will be moved to a staging area for additional hazard categorization sampling. The number of opening and staging areas necessary depends on site-specific circumstances, such as scope of operation, the accessibility of drums in their original positions, and the perceived hazards.

- Drums should be resealed as soon as possible using plugs or new bungs. Drums that cannot be sealed should be overpacked prior to movement to the staging area.

5.3.2 Leaking/Deteriorated Drums

- Once in-place monitoring has been conducted, leaking or structurally unsound deteriorated drums will be placed into overpack drums. This initial overpacking will limit the potential for spills or releases that could jeopardize worker safety. No ground personnel will be allowed in the immediate area during this overpacking activity.

- If a drum cannot be moved without running the risk of rupture, its contents will be transferred using an explosion-proof pump compatible with the material being transferred. All drums and containers used during this transfer will meet appropriate DOT, OSHA, and EPA regulations for the wastes they contain.

- Once this overpacking activity is complete, the overpack will be labeled and moved to the staging area for sampling and final disposition.

5.3.3 Empty/Crushed Drums

Upon verification that drums are empty and monitoring results indicate no hazard to personnel, the drum or drum remnants will be moved to a designated staging area.

5.3.4 Characterized Drums

Characterized drums will be handled in strict accordance with the procedures specified in the MSDS for the material they contain.

5.3.5 Shock-Sensitive Drums

The handling of shock-sensitive drums is extremely hazardous. Upon their initial discovery, all personnel should move to a safe distance and contact with the program's Certified Industrial Hygienist. There is no one universal procedure that can be established for the handling of all shock-sensitive drums. Each situation must be carefully examined and individual procedures developed and followed for each.

- Continuous communications will be maintained between the drum handling area and both the Site Health and Safety Officer and the Site Superintendent until handling operations have been completed.

5.3.6 Laboratory Packs

- Laboratory packs should be considered to hold shock-sensitive wastes until otherwise characterized.

5.4 Drum Sampling

- Each drum will be clearly marked with a unique identification number and the identified characteristics of the drum contents so that the compatibility with other drums can be assessed and the drums can be stored, handled, or disposed of properly.

- Drum sampling will only occur in a designated area after handling and opening operations have been completed. Any problems or unique situations encountered during previous activities will be conveyed to the sampling team.

- Drums will not be stood upon and excessive contact with drums should be avoided.

- One of the project plans for each particular drum sampling project will contain a detailed sampling approach that includes:
  Background information about the waste
  Types of sampling devices and containers to be used
  The number, volume, and locations of samples to be taken.

5.5 Cylinder Handling

Visual inspection of compressed gas cylinders will be performed to assess the degree of hazard associated with each cylinder and to determine its applicable handing procedure. IT Procedure HS306, Handling Compressed Gas Cylinders with Unknown Contents, will be adhered to for each such activity.

5.6 Spill Prevention

Due to the nature of drum/container handling activities, spills of hazardous materials to the environment are possible and must be prepared for. The following measures will be taken to minimize this possibility:

- The designated drum opening area will be diked and lined to contain all potential spills and discharges that may occur during the initial drum opening activity.
- A sufficient quantity of spill control materials and equipment will be accessible to all drum operation areas, including initial investigation, segregation, opening, sampling and storage areas. The specific types and quantities of this equipment will be specified in the project SHSP.
- Personnel will be trained to respond to incidental drum releases where the spilled material can be absorbed, neutralized, or otherwise controlled at the time of release by personnel in the immediate release area.

5.7 Personal Protective Equipment

The project SHSP will designate the level of personal protective equipment (PPE) that will be required to be worn by personnel performing drum handling activities. Generally, level B PPE utilizing air-supplied respirators will be used when dealing with drums of unknown content.

5.8 Fire Protection

An adequate number of fire extinguishers will be available and ready for use to control incipient stage fires. Extinguishers will be located in each of the drum handling areas established at the site. All equipment and tools used to open drums will be made of a nonsparking material to prevent sources of ignition.

6.0 *Exception Provisions* (No Exceptions to the Requirements of this Policy are Permitted)

7.0 *Cross References*

- 29 CFR 1926.65

- NIOSH/OSHA/USCG/EPA - Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities

- EPA - Standard Operating Safety Guides

- HS052 Health and Safety Plans

- HS306 Handling Unknown Compressed Gas Cylinders

- HS600 - Personal Protective Equipment

8.0 *Attachments*

8.1 Attachment 1, Responsibility Matrix

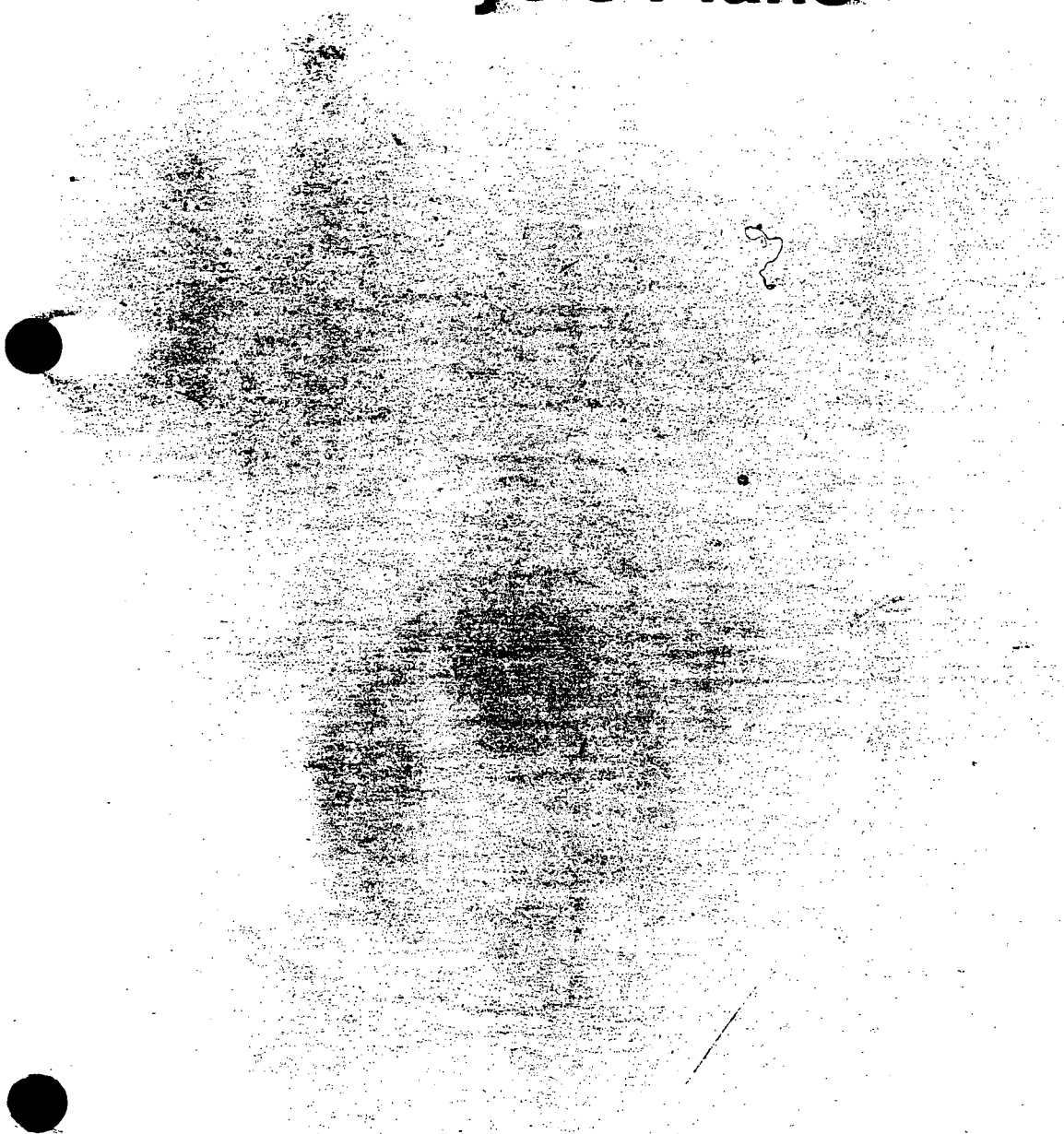
Appendix B
Requirements for the Preparation of a Sampling and Analysis Plan (USACE, 1994)

EM 200-1-3
1 September 1994

US Army Corps
of Engineers

ENVIRONMENTAL QUALITY

Requirements for the Preparation of Sampling and Analysis Plans



ENGINEER MANUAL

CEMP-RT
CECW-E

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

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Manual
No. 200-1-3

1 September 1994

Environmental Quality
REQUIREMENTS FOR THE PREPARATION OF SAMPLING AND ANALYSIS PLANS

1. Purpose. This manual provides guidance for preparing project-specific sampling and analysis plans (SAP) for the collection of environmental data. It also provides standard operating procedures that can be utilized, if appropriate, in the preparation of these SAPs.

2. Applicability. This manual applies to HQUSACE elements, major subordinate commands, districts, laboratories, and field operating activities having responsibility for sampling and analysis of environmental samples. This includes, but is not limited to, execution of the following programs: Defense Environmental Restoration Programs; Base Realignment and Closure; Superfund; Civil Works; Military Construction; installation environmental compliance; Defense Logistics Agency; Department of Energy; work for others; and any construction projects involving hazardous, toxic, and radioactive waste (HTRW).

FOR THE COMMANDER:

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CECW-E

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Table of Contents

Chapter 1
Introduction

1-1. Purpose

This manual provides guidance for preparing project-specific sampling and analysis plans (SAP) for the collection of environmental data.

1-2. Applicability

This manual applies to Headquarters, U.S. Army Corps of Engineers (HQUSACE) elements, major subordinate commands, Districts, laboratories, and field operating activities having responsibility for sampling and analysis of environmental samples. This includes, but is not limited to, execution of the following programs: Defense Environmental Restoration Programs; Base Realignment and Closure; Superfund; Civil Works; Military Construction; installation environmental compliance; Defense Logistics Agency; Department of Energy; work for others; and any construction projects involving hazardous, toxic, and radioactive waste (HTRW).

1-3. References

Required and related publications are listed in Appendix A, "References."

1-4. Functional Equivalencies

The SAP has replaced the document that was formerly known as the chemical data acquisition plan. SAPs prepared in accordance with the guidance provided by this manual are intended to be functionally equivalent to U.S. Environmental Protection Agency (EPA) sampling and analysis plans, field sampling plans, and quality assurance project plans prepared under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and to data collection quality assurance plans and data management plans prepared under the Resource Conservation and Recovery Act (RCRA). To reflect current EPA guidance, the SAP is divided into two parts: a field sampling plan (FSP) and a quality assurance project plan (QAPP). The FSP addresses the field activities, including all aspects of sampling and drilling. The QAPP addresses the data quality objectives, specific quality assurance (QA) and quality control (QC) activities, and laboratory activities designed to achieve the data quality goals of the project. This manual contains requirements for format and contents of the SAP and instructions for specifying and executing sampling, analysis, and related tasks for measurement of chemicals in the environment. Certain situations may require that the SAP be written differently than the format described in this manual. For example, an RCRA investigation may have additional requirements that cannot be satisfied by following only the guidance in this manual. For remedial action projects, a separate monitoring well installation plan may be specified. Many states have their own regulations regarding underground storage tanks, which may impact SAP preparation. This manual complements existing USACE guidance (the required references in Appendix A) as well as USACE guidance that is currently being developed.

1-5. Discussion

The SAP is a document prepared by an architect-engineer firm, a remedial action contractor, or USACE to describe the project requirements for all field activities, laboratory activities, and contract deliverables related to the acquisition and reporting of chemical data for hazardous, toxic, and radioactive waste (HTRW) response activities. Investigative projects include: preliminary assessment/site inspections (PA/SI), remedial investigation/feasibility studies (RI/FS), engineering evaluation/cost analyses, RCRA facility assessments, RCRA facility investigations, and corrective measure studies. In addition to investigative projects, this manual may be used for developing plans for data collection activities such as pre-design bench and pilot studies, remedial action monitoring, and post-closure monitoring, etc. The size and complexity of a project will be reflected in the SAP. Although this document is applicable to radioactive wastes, chemical agents, and biological wastes, additional guidance may be necessary to prepare SAPs involving these materials. When chemical data are acquired, the SAP is one component of the overall project work plan. SAPs are required for each contractor work order. All details of field and laboratory activities must be described in the FSP and QAPP, respectively. These documents must be submitted to the appropriate USACE technical staff for review, comment, and approval. Once approved, the SAP represents the standard to which all activities are compared to assure compliance. In the case of contractor execution, the approved SAP is contractually binding.

1-6. Relationship to the Project Work Plan

For USACE HTRW investigative projects involving generation of analytical data, the SAP is included as an attachment to the project work plan. For those projects in which a work plan is not required, such as certain remedial actions, the SAP must be a stand-alone document.

a. Project work plan. The project work plan is an "umbrella" document that addresses, but is not necessarily limited to, the following subjects.

(1) Project introduction. This section includes a brief summary of the site: size and location; ownership history; authority under which the work is to be performed; and the purpose and scope of the work plan.

(2) Site description and history. This section includes the geology of the site, building structures, if any, topography of the site, etc. It also includes a brief history of the site in terms of former activities and waste disposal practices which may have contributed to potential contamination over the years.

(3) Previous investigations. This section discusses previous investigation activities and other response activities at the site. It also discusses any problems and/or data anomalies.

(4) Project objectives (long- and short-term). This section explains the purpose of the project: the regulatory framework under which the work is being conducted; what goals are to be met; and what questions are to be answered. In the case of a PA/SI, the objectives might include a determination of whether there is enough evidence to support the need for an RI/FS. In the case of an RI/FS, the objectives might include site contamination characterization in terms of extent and concentration and the screening of remedial action alternatives. Applicable or relevant and appropriate requirements should be addressed. Much of the information is this section is helpful in guiding the preparation of the SAP.

(5) Data gaps. This section provides information regarding data gaps that need to be filled in order to make project decisions, such as defining the extent of contamination and choosing remedial action alternatives.

(6) Data quality objectives (DQOs). This section describes how data will be used to make project decisions. This section may serve as a general scoping guide for data acquisition activities which are defined in the SAP.

b. SAP. The attachments to the project work plan (SAP, site safety and health plan, etc.) provide details of the specific data collection activities that are designed to support the objectives of the project, as set forth in the work plan. Information in the project work plan and SAP should not be redundant. Project-specific DQOs, including QA objectives for precision, accuracy, representativeness, completeness, comparability, and detection level are addressed in the SAP. QA objectives are applicable to both sampling and analytical portions of the project.

1-7. Technical Project Planning

USACE and/or contractor technical planning teams are responsible for developing project-specific data collection programs that define the quality and quantity of data needed to perform all the engineering and scientific evaluations required for the project. Data users will determine initial data needs in order to perform specific evaluations and make the engineering and scientific judgments required to complete the necessary activities leading to site closeout. Implementors provide input to planning specific data collection tasks and are responsible for task execution. This manual provides guidance to implementors for preparing SAPs for conducting field and analytical work and is a source of standard operating procedures (SOP). This manual provides both data users and implementors with a vehicle to prescribe sampling and analytical protocols necessary to achieve data quality objectives dictated by the technical project planning phase.

1-8. Overview of Manual

This manual consists of four chapters and eleven appendices. Chapter 1 presents an overview. Chapter 2 presents guidelines for use of the engineering manual. Chapter 3 presents format and content requirements of FSP and QAPP components of SAPs. Chapter 4 contains guidelines for developing sampling and analysis protocols when those protocols in Appendices C, D, E, F, G, and H are not appropriate. Appendix A contains a list of required and related publications. Appendix B contains chemical analysis requirements. Appendix C contains instructions for collecting environmental samples from various media. Appendix D contains hazardous waste sampling instructions. Appendix E contains sample manipulation instructions. Appendix F contains sample documentation and shipping instructions. Appendix G contains analytical techniques/procedures instructions. Appendix H contains QA/QC procedures: Appendix I contains a table of holding times, preservatives, and sample containers for various parameters. Appendix J contains a list of acronyms and definitions. Appendix K contains a review checklist for SAPs. This manual will be revised as needed by modifying/adding instructions to incorporate changes and innovations within the environmental community, as well as changes in USACE policy.

Chapter 2
Utilization of the Engineer Manual

2-1. General

This section discusses how the engineer manual may be used to prepare, review, and use an SAP. This section also describes how the engineering manual may be used by USACE personnel as a source for specifying sampling instructions when preparing the scope of work (SOW) or, in the case of a site remediation project, the plans and specifications for the project. This section very briefly describes how to execute an SAP and verify compliance with the field and analytical procedures specified in the SAP.

2-2. Scope of Work Preparation

This engineer manual contains information that may be used during the technical planning of projects and generation of project SAPs. It is a USACE mission to characterize and remediate HTRW-contaminated sites in an efficient, cost-effective, and technically sound manner. To attain this goal, technical planning teams may utilize other USACE guidance for standard outlines on scoping HTRW investigations and HTRW technical project planning. Before the section of the SOW (in the case of a site remediation project, the plans and specifications) that addresses preparation of the SAP is drafted, it is important that the needs and expectations of the customer and regulators be understood. Once these expectations are clearly understood, this information may be relayed to the technical planners. Site strategies and project objectives can then be defined and in turn be used to define data needs to complete the work. These data needs are then used to identify data collection options. Once the data collection options are defined, the project technical planners select an appropriate project data collection program. The appendices of this engineering manual contain sampling and analytical standard operating procedures (SOPs) within the instructions that may be considered when identifying the data collection options. These then undergo screening to select sampling and analytical procedures that will make up the data collection program. Data quality objective (DQO) statements must finally be defined that describe the data collection program outlined. USACE personnel may specify in the SOW or plans and specifications which of these instructions should be utilized for preparation of the SAP, or they may simply state that this manual should be used as a source of SOPs, which are then elaborated upon for inclusion within the SAP. Contractors providing services for USACE may have their own sampling and analytical SOPs that would be suitable for a given project. In these cases, this manual provides a format for structuring the contractor's instructions for inclusion in the SAP. This will ensure continuity in the HTRW program. If project-specific objectives and strategies cannot be satisfied by any of the instructions in the appendices, Appendix A contains a list of references for alternate sampling and analytical methods. Section 4-3 of this engineering manual discusses how to develop new sampling and analysis instructions.

2-3. SAP Preparation

This section describes how to use the engineer manual to prepare an SAP. When preparing an SAP, the authors should consult other documents for special requirements that may be applicable to the specific project. For example, if the HTRW site is a Superfund site, it would be appropriate to consult EPA/540/G-89/004 (1988). If the site is being remediated under the RCRA, the appropriate RCRA investigative guidance documents should be reviewed. Other USACE guidance on HTRW technical project planning may also be used. Once a literature review has been completed, the following six-step approach is suggested to prepare the SAP. The SOW or plans and specifications will specify the extent to which the architect/engineer or remedial action contractor will interact with USACE in proceeding with the six-step approach.

a. Step 1--Consult with technical planners. Step 1 is not applicable to USACE in-house personnel because USACE technical planners (technical managers and/or project scientists/engineers) actually prepare the SAP. However, USACE technical planners may interact directly with their customer to obtain information. Contractors working under an agreement with USACE should initially consult with USACE technical planners to obtain information concerning the project. In some instances contractors may also interact directly with USACE's customer to obtain this information. There are two reasons to consult with the technical planners. The first reason is that the technical planners may be used as resources for important facility information and data from previous investigations. The second reason to consult technical planners is to obtain as much information as possible regarding site constraints. Some of the more common site constraints are listed below.

(1) Physical constraints. Physical constraints include the geographical location of the site, geological information, topographical information (surveys, area/photographs), and climatological information.

(2) Chemical constraints. Chemical constraints include the nature of contamination, the presence of unexploded ordnance, the presence of radioactivity at the site, and the presence or history of chemical agent testing or disposal.

(3) Regulatory constraints. Regulatory constraints include requirements for worker health and safety, requirements for investigation-derived wastes, and regulations that are driving the investigation (RCRA/CERCLA, etc).

(4) Management constraints. Management constraints include site security, funding, scheduling, customer preferences, etc.

b. Step 2--Review data needs. It is important to develop specific data needs based upon the purpose for which the data are to be used. By reviewing the data needs, one should be able to answer such questions as, "Are discrete and/or composite surface soil samples needed?" Another important issue that should be addressed is the analytical detection limits. Much lower detection limits may be required for a risk assessment than to determine contaminated areas that may be defined by an action level that is in the parts-per-million range. Before writing the SAP, a full understanding of the data needs for a given project is necessary because they dictate which sampling and analytical methodologies will be acceptable for potential inclusion into the data collection program established for the project. DQO statements are then prepared based on the data collection program chosen. The project work plan and attachments must clearly describe the data collection program to be implemented, along with the associated project DQO statements. The project work plan/SAP will also outline precision, accuracy, and completeness goals that are based on the intended use of the data. As an attachment to the project work plan, one of the major functions of the SAP is to complement the project work plan by addressing sampling and analytical procedures and defining the applicable quality control (QC) criteria that will satisfy project DQOs. For example, consider the following scenario where the completeness objective affects the sampling methodology decision.

> The USACE must determine whether volatile organic compounds from a former chemical plant site are being discharged to the groundwater and are migrating offsite. USACE proposes sampling each of the available 32 offsite springs that are fed by groundwater flowing under the site. The USACE technical planners require data from at least 29 springs (completeness goal of 90 percent) to safely support a hypothesis that volatiles are migrating offsite through groundwater. If five of the proposed springs have low flows and do not create large pools that can be sampled using a conventional sampling method that is suited for sampling low-flow springs for volatiles, alternate sampling methods will have to be developed.

c. Step 3--Develop/review data collection options. Data collection options are feasible sampling and analytical strategies, identified by the technical planners, that will undergo screening in order to develop an appropriate data collection program to be implemented for the project. These options are developed based upon the data needs previously identified. The appendices of this guidance document contain instructions that include a variety of SOPs applicable to different matrices and/or parameters. This step, as it pertains to sampling, should focus on location and frequency of samples. For example, some proposed sample locations may be in areas not attainable by standard sampling means. For this reason, it may be necessary to obtain an all-terrain drill rig to collect boring samples. On the other hand, a surface water sample may be needed from a swiftly flowing river; therefore, it would not be practical or safe to propose a sampling method in which the sampler would have to wade into the stream to collect the sample. The analytical options should consider the required level of data quality, the necessity of confirmation of analyte identification, required detection limits, and any time constraints identified for the project. For example, if the project required determining the extent of contamination of soils over a large area, it would be cost-effective to find an analytical screening method that would be able to eliminate the need for submitting a large number of analytical samples to the primary laboratory. If soil excavation and sampling were being performed simultaneously to determine the depth of contamination, field screening of samples would help eliminate "downtime" for heavy equipment operators. On the other hand, if a site is a disposal area where little background information is available, the potential of contamination from unknown compounds may be high. In this case, a limited number of samples may be collected and analyzed initially with a lengthy analytical protocol to identify contaminants of concern. The analytical data from this initial phase would then be used to plan future sampling and focus analytical events. In this scenario, a phased approach is taken to allow thoughtful decisions to be made for each phase based upon information previously gathered. This scenario would also benefit from the confirmation of organic analyte identification that mass spectral (GC/MS) detection affords.

d. Step 4--Screening of data collection options. After Steps 1 through 3 have been completed, informed decisions can be made with regard to screening and selecting the optimum sampling and analytical strategy from the data collection options identified in Appendices C through H of this engineering manual, or another reference, for incorporation into the project data collection program. Figure 2-1 presents a flow scheme of the screening process for selecting sampling and analytical methods. Sampling and analytical methods should be screened and selected after consideration of the following four issues: schedule, regulatory, technical, and budget (cost). The technical issue may be further defined by the effectiveness and implementability of the method. Following is a brief discussion of the importance of each criterion.

(1) Schedule. Impacts from scheduling may come as a result of a number of factors. These may include time constraints imposed by regulators, permits, etc.; limitations due to permissible weather conditions for sampling; and the expected duration of the work effort, equipment downtime, etc. This type of information should have been gathered through the planning process and must be considered at this time.

(2) Regulatory. Impacts from the regulatory authorities vary significantly for each individual project. These impacts should be considered after reviewing site-specific information.

(3) Technical. The technical criteria may be divided into effectiveness and implementability issues.

(a) Effectiveness. An analytical and sampling method must be able to satisfy client, project technical planners, and regulatory preferences/requirements, while providing data that meet the project data use objectives and DQOs. Sampling methods must also be able to satisfy sampling strategies (i.e., discrete and composite sampling requirements).

(b) Implementability. The primary purpose of this criterion is to determine whether the proposed analytical and sampling method can be safely used in whole or in part at the site. For example, a site physical constraint discovered in Step 1 may preclude the use of a normal drill rig on some areas of the site.

(4) Budget (cost). Once a decision has been made that the analytical and sampling method is both effective and implementable, a determination should be made as to whether the proposed method meets the budget requirements for the project. For example, it may be determined that both contract laboratory program (CLP) and SW846 analytical protocols are effective and implementable for the project, but the budget cannot afford to support the more expensive CLP protocols.

e. Step 5--Develop data collection program. After completing Steps 1 through 4, the project data collection program must be defined by the technical planning team. If it is determined from the screening process in Step 4 that the sampling and/or analytical methods in the appendices or other existing references are not appropriate, Chapter 4 of this engineering manual can be used to develop site-specific or non-standard methods. This would be a likely solution to the scenario presented in Step 2 of this section.

f. Step 6--Review requirements for format and contents of SAPs. Chapter 3 of this engineering manual discusses the general format and content requirements for the FSP and QAPP portions of the SAP. A good working knowledge of these requirements is necessary to understand the type of information required to draft an SAP and determine if additional sources of information are required. Appendix I contains standard protocols for such things as analytical holding times, sample preservation, sample container requirements, etc. These protocols should be addressed in the SAP. Appendix K contains a checklist for reviewing the SAP.

2-4. SAP Review/Approval

This section briefly outlines the review/approval process for an SAP. The SAP should be reviewed to determine whether it provides data that satisfy customer and technical planner preferences, whether it satisfies the data use and data quality objectives, and whether it is compatible with all site constraints. Reviewers should use the "review checklist" found in Appendix K as a guide for reviewing the SAP. This checklist is a very general guide and contains information that typically should be contained in an SAP. EPA guidance documents for preparing CERCLA/RCRA investigative work plans may also be consulted. After the SAP has been reviewed, the document can be accepted as is or returned to its authors for review comment resolution. Once the SAP has been approved, appropriate personnel sign the signature page, and the SAP becomes a contractual document. The USACE personnel that will sign the SAP will be determined on a project-specific basis by the technical planning team. It is recommended that the USACE technical manager sign the title page of the SAP and that the USACE chemist sign the title page of the QAPP. Any

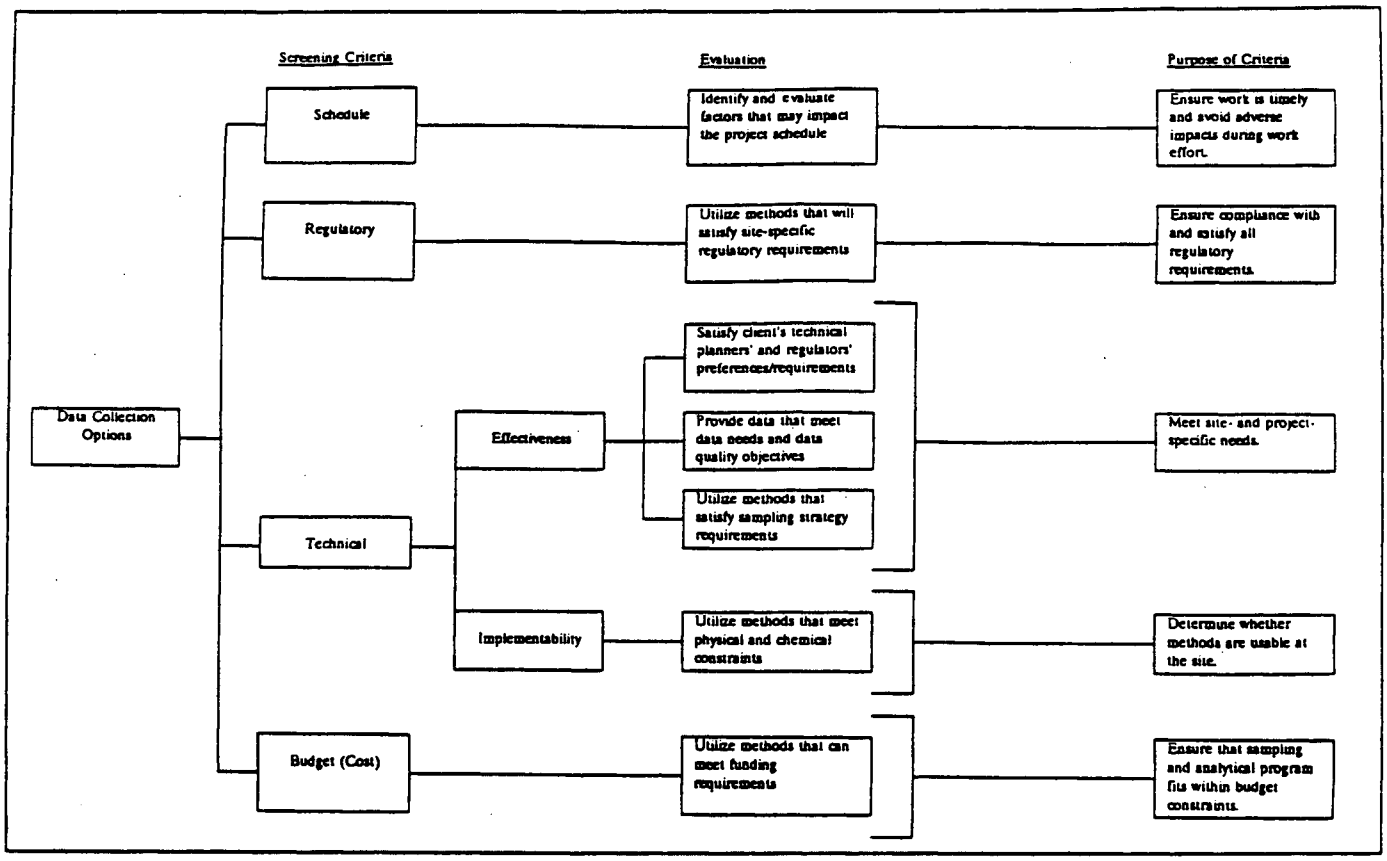

Figure 2-1. Screening process for selecting sampling and analytical methods

deviations from the approved document must receive written approval from the appropriate USACE personnel.

2-5. SAP Execution and Compliance

This engineer manual may be used by USACE contractors and USACE oversight personnel as a guide for either executing the SAP or monitoring compliance with the SAP. Before data collection activities are implemented with either contractor or USACE resources, an approved SAP must be in place. While implementing the SAP, compliance with the SAP should be documented by collecting and submitting quality assurance/quality control (QA/QC) samples and submitting daily chemical quality control reports (DCQCR). While data collection activities are being performed, the sampling team should communicate daily with appropriate USACE personnel regarding project status. This may be accomplished with DCQCRs. QA/QC samples should be submitted by the sampling team as discussed in the project-specific FSP.

a. Audits. USACE personnel conduct field audits and QA monitoring for all field sampling activities conducted as part of the HTRW program. This includes field activities executed in-house or by contractors for any phase of work from initial investigation to post-closure monitoring. This oversight is necessary to ensure that approved procedures, as specified in the SAP, are used to perform the work. Field audits include monitoring critical activities, such as well installation and well development, placement of other types of sample access devices (e.g., passive soil gas collection media), decontamination of equipment used to generate samples or other activities that could cause cross-contamination, sample collection from all media (i.e., air, groundwater, surface water, soil, sediment, waste, etc.), and post-sample collection activities (packaging/shipping). Field audits should be scheduled as early in the activity as possible to identify procedures that could cause problems with the sampling and analytical results. Another mechanism for monitoring field activities as they are occurring is to perform desk audits. This is usually done by reviewing DCQCRs and field logs while the field activities are in progress. The SOW or plans and specifications should have a requirement stating that these reports be supplied on a periodic basis (e.g., daily or weekly).

b. Field control samples. To complement field and desk audits, field control samples should be generated. Field control samples are generally composed of duplicates, splits, QA split samples, rinsate blanks, and trip blanks. These samples are generally used to monitor field sampling and packaging/shipping activities. These samples are sent to the primary project laboratory as well as the project-specific designated QA (USACE Division) laboratory. In addition to monitoring sampling activities, analysis of field control samples by the QA laboratory enables USACE to monitor the quality of the analysis by the primary laboratory.

c. Corrective action. The FSP should also address notification and corrective actions that should be followed by field and laboratory personnel if there are deviations from the SAP or problems with samples upon receipt at the laboratory. Typical problems/deviations include, but are not limited to, the following: improperly preserved samples, improper chain-of-custody documentation, broken sample containers, sample relocation, insufficient volume, etc. As a minimum requirement, the FSP should state that significant changes or deviations to the approved SAP should not be made without the written approval of USACE. The QAPP should also describe corrective action procedures that may be taken if field and/or analytical procedures deviate from the requirements in the SAP. Example corrective action measures include, but are not limited to, reanalysis of samples, resampling with additional analysis of new samples, reanalysis of QA/QC samples (matrix spikes, laboratory duplicates), or no action with the data used as estimated quantities.

Chapter 3
Sampling and Analysis Plan–Format and Contents

3-1. General

This section contains general guidance for the format and contents of a sampling and analysis plan (SAP), including a brief discussion of the contents of each of the major elements.

3-2. Format Requirements

The SAP consists of two parts: a field sampling plan (FSP) and a quality assurance project plan (QAPP). The FSP provides guidance for all fieldwork by defining in detail the sampling and data-gathering methods to be used on the project. The QAPP describes the policy, organization, functional activities, and quality assurance and quality control protocols necessary to achieve the data quality objectives (DQOs). The FSP and QAPP should be submitted as a single document (although they may be bound separately to facilitate the use of the FSP in the field). The FSP and QAPP are prepared prior to any field activities, but the FSP and QAPP may be amended or revised several times during the investigation activities using the protocol outlined in Section 2-4 of this engineer manual. Table 3-1 contains the typical elements that should appear in the FSP and QAPP. All of the elements identified in Table 3-1 may not be appropriate for every project. In these instances, the format presented in Table 3-1 should still be used even though some elements may not be relevant. The element that is not relevant should be retained and identified as not being relevant. No major element from Table 3-1 should be deleted. The major elements of the FSP and QAPP which appear in bold type within Table 3-1 are discussed in Section 3-3.

3-3. Content of Major Elements

The FSP describes the field activities that must be performed and defines the procedures and methods that must be used to collect field measurements and samples. Issues addressed by the FSP include collection of geophysical data; installation of soil borings and groundwater monitoring wells; procedures for collection of multimedia samples, field measurements, and quality assurance/quality control (QA/QC) samples; and requirements for sample chain of custody, documentation, and shipping. The FSP also addresses investigation-derived wastes, contractor daily chemical quality control reports, corrective action procedures, and the schedule for field activities. The QAPP primarily focuses on the analytical methods and QA/QC procedures that are used to collect and analyze the samples. Issues addressed by the QAPP include the project description, project laboratory organization, and the responsibilities of key lab personnel; QA objectives; sampling locations and procedures; sample handling, custody, preservation, and holding time requirements; analytical procedures; equipment calibration; internal quality control procedures of the laboratory; assessment of the data for precision, accuracy, and completeness; corrective actions; data reduction, review, validation, and reporting; preventative maintenance; performance/system audits; and QC reports to management. There will generally be some overlap of site-specific information addressed by the FSP and QAPP. Since the FSP will be taken into the field and will be the most important source of information for the field team, all of the required information should be presented in the FSP. Site-specific information that is contained in the FSP may be referenced in the QAPP. The minimum requirements for the contents of FSPs and QAPPs are discussed below. Additional information may be obtained from QAMS 005/080, SW-846, EPA/530/SW-88/055, EPA/540/2-88/005, and EPA/600/S8-89/046.

a. Title page. The title page should be the first page of the SAP. The following items should appear on the title page: name of the document, site name and location, USACE contract number (if applicable), authority under which the activities are being performed (CERCLA, RCRA, etc.), and date of preparation. If tasks performed under the SAP are executed by a contractor, Figure 3-1 is an example signature block that should appear at the bottom of the title page.

b. Table of contents. This should be a very general table of contents that outlines the layout of the SAP. Table 3-2 is an example.

c. Field Sampling Plan. The following section briefly describes the contents of an FSP. FSPs are site-specific and may include additional elements (the references presented in Appendix A contain additional information).

(1) Title page. The FSP should have an abbreviated title page that includes the name of the document (e.g., Phase I Remedial Investigation Field Sampling Plan) and the date it was prepared.

Table 3-1
SAP Format Requirements

Title Page
Table of Contents

I Field Sampling Plan

Title Page
Table of Contents

1.0 Project Description
- 1.1 Site History and Contaminants
- 1.2 Summary of Existing Site Data
- 1.3 Site Specific Sampling and Analysis Problems

2.0 Project Organization and Responsibilities

3.0 Scope and Objectives

4.0 Field Activities
- **4.1 Geophysics**
  - 4.1.1 Rationales
    - 4.1.1.1 Method
    - 4.1.1.2 Study Area Definition and Measurement Spacing
  - 4.1.2 Procedures
    - 4.1.2.1 Equipment
    - 4.1.2.2 Preliminary Method Testing and Early Termination Procedures
    - 4.1.2.3 Instrument Calibration and Quality Control Procedures
    - 4.1.2.4 Field Progress/Interpretation Reporting
    - 4.1.2.5 Measurement Point/Grid Surveying
    - 4.1.2.6 Data Processing
    - 4.1.2.7 Potential Interpretation Techniques
- **4.2 Soil Gas Survey**
  - 4.2.1 Rationales
    - 4.2.1.1 Soil Gas Sample Locations
    - 4.2.1.2 Sample Collection and Field and Laboratory Analysis
    - 4.2.1.3 Background, QA/QC, and Blank Samples and Frequency
  - 4.2.2 Procedures
    - 4.2.2.1 Drilling Methods and Equipment
    - 4.2.2.2 Materials (Casing, screen, etc.)
    - 4.2.2.3 Installation
    - 4.2.2.4 Sampling Methods
    - 4.2.2.5 Field Measurement Procedures and Criteria
    - 4.2.2.6 Documentation
- **4.3 Groundwater**
  - 4.3.1 Rationales
    - 4.3.1.1 Monitoring Well Location and Installation
    - 4.3.1.2 Sample Collection and Field and Laboratory Analysis
    - 4.3.1.3 Upgradient, QA/QC, and Blank Samples and Frequency
  - 4.3.2 Monitoring Well Installation
    - 4.3.2.1 Drilling Methods and Equipment
    - 4.3.2.2 Materials
      - 4.3.2.2.1 Casing/Screen
      - 4.3.2.2.2 Filter Pack, Bentonite, Grout
      - 4.3.2.2.3 Surface Completion
      - 4.3.2.2.4 Water Source
      - 4.3.2.2.5 Delivery, Storage, and Handling of Materials
    - 4.3.2.3 Installation
      - 4.3.2.3.1 Test Holes
      - 4.3.2.3.2 Soil Sampling and Rock Coring During Drilling
      - 4.3.2.3.3 Geophysical Logging
      - 4.3.2.3.4 Borehole Diameter and Depth

(Sheet 1 of 4)

Table 3-1 (Continued)

- 4.3.2.3.5 Screen and Well Casing Placement
- 4.3.2.3.6 Filter Pack Placement
- 4.3.2.3.7 Bentonite Seal
- 4.3.2.3.8 Cement/Bentonite Grout Placement
- 4.3.2.3.9 Concrete/Gravel Pad Placement
- 4.3.2.3.10 Protective Cover Placement
- 4.3.2.3.11 Well Identification
- 4.3.2.3.12 Well Development
- 4.3.2.3.13 Well Survey
- 4.3.2.3.14 Alignment Testing
- 4.3.2.3.15 In situ Permeability Testing
- 4.3.2.4 Documentation
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COMMITMENT TO IMPLEMENT THE ABOVE SAMPLING AND ANALYSIS PLAN

Contractor's Project/Task Manager, (print)	Signature	Date
Contractor's QA Manager (print)	Signature	Date
Other as Appropriate/Affiliation* (print)	Signature	Date
Other as Appropriate/Affiliation* (print)	Signature	Date
Other as Appropriate/Affiliation* (print)	Signature	Date

* Commitment signature is required for any ancillary sampling, analytical, or data-gathering support provided by a contractor or subcontractor. For example, the Contractor's laboratory QA manager or director should sign the title page if analytical services are provided.

Figure 3-1. Example signature block

(2) Table of contents. The table of contents should include a listing of the FSP elements, any appendices that are required to augment the FSP, tables, and figures.

(3) Project description. This section of the FSP should be as specific as possible. Sufficient information should be included in this section to permit a technical person unfamiliar with the project to evaluate the sampling and analytical approach. A description of the location, size, and important physical features of the site, such as ponds, lagoons, streams, and roads, should be included (a figure showing the site location and layout would be helpful). A chronological site history including descriptions of the use of the site, complaints by neighbors, permitting, and use of chemicals should be provided. The historical data from previous sampling efforts at the site should be identified and summarized. An assessment of the quality of the historical data should be included as well as a discussion of problems previously encountered. The effects of this information on the current project should also be discussed. The site background section of the FSP should also indicate startup and ending dates, including those for preliminary studies and field and laboratory activities. If any of these items are discussed in the project work plan, they do not need to be repeated in the FSP, but they should be incorporated by reference.

(4) Project organization and responsibilities. This element of the FSP identifies key field personnel or organizations that are necessary for each field activity during the project. For remedial action and/or construction projects, this element will be expanded to include key personnel for all activities including project planning, since no overall project work plan is required. A table or chart showing the organization and lines of authority should be included. When specific personnel cannot be identified, the organization with the responsibility should be listed. The organizational chart should also include all subcontractors and their key points of contact. Separate organizational charts for subcontractors may also be needed. The organizational chart should identify QA managers, including those of subcontractors, and should illustrate their relationship to other project personnel. The QA managers should be organizationally independent of the project management so that the risk of conflict of interest is minimized. This section of the FSP should also describe the responsibilities of all project field personnel, including QA managers. This summary should designate responsibility for planning, coordination, sample collection, disposal of investigation-derived waste, and sample custody.

(5) Scope and objectives. Specific objectives of a sampling effort that describe the intended uses of data should be clearly and succinctly stated. These objectives should satisfy not only the intended uses of the data, but also client preferences. General QA/QC procedures should be discussed. General QC procedures (collection of sample replicates and blanks) are implemented in the field to support the general QA objectives identified for the project. Sections B-4 and B-8 of Appendix B contain additional information on QA objectives and QC procedures, respectively. QA/QC samples are also defined as types of samples collected by the contractor and are outlined for the project under paragraph (6). This section of the FSP should discuss special situations where site access may need to be obtained from private property owners, if applicable.

(6) Field activities.

(a) Rationale. This section of the FSP discusses the rationale for each of the field activities. Subsections of the FSP that address each of the matrices to be sampled should include the rationale (statistical judgmental, and/or random basis) behind the required number of field samples; the strategy for selection of the particular sampling location (as discussed in Appendix C-1); a summary of the required number of field, background/upgradient, and field QC samples; and the type of samples (composite or discrete). QA samples are replicates of field samples that are collected by the contractor and sent to the designated government QA laboratory for analysis. These samples are used by USACE for early detection of any problems with the contractor's field sampling, documentation,

Table 3-2
SAP Table of Contents Example

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8.0 Contractor Chemical Quality Control
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packaging, or shipping procedures. QC samples are also replicates of field samples that are sent to the contractor's laboratory to assess the quality of the contractor's field sampling methods. QC samples should be disguised as individual field samples by using a sample numbering system similar to that used for all field samples. This is done so that the sample is sent "blind" to the laboratories. This section of the FSP should also include a list of all measurements that will be made during the project. It is recommended that parameters planned for each sample be summarized in tabular form. This table should indicate the total number of samples for each sample location, including quality assurance (QA) and quality control (QC) samples. For projects involving a large number of samples or analyses, it may not be possible to include all QC samples in a single table. For such cases, two or more tables may be necessary--the first to summarize the primary (non-QC) samples, and the other to show which QC samples are associated with which analyses. Table 3-3 is an example of a sample summary table that has been used on other projects. The discussion of field QC samples

Table 3-3
Example Sample Table

Sample Location	Sample Depth	Sample Number (Primary Lab)	QC Sample Number (Primary Lab)	Associated Trip Blank Number (Primary Lab)	Associated Rinsate Blank (Primary Lab)	Sample Number (QA Lab)	Associated Trip Blank Number (QA Lab)	Associated Rinsate Blank (QA Lab)	EPA 8240	EPA 8270	EPA 239.2	EPA 418.1
T-1	4-6 ft bgs	T-1	-	TB-1	RB-1	-	-	-	X	X	X	X
T-2	6-8 ft bgs	T-2	-	TB-1	RB-1	-	-	-	X	X	X	X
T-3	2-4 ft bgs	T3/S-1	T3/S-4	TB-1	RB-1	T3/S-1/QA	TB-1/QA	RB-1/QA	X	X	X	X
	4-8 ft bgs	T3/S-2	-	TB-1	RB-1	-	-	-	X	X	X	-
	8-12 ft bgs	T3/S-3	-	TB-1	-	-	-	-	X	-	-	-
T-4	6-8 ft bgs	T-4	-	TB-2	RB-1	-	-	-	X	X	X	X
T-5	2-4 ft bgs	T5/S-1	T5/S-4	TB-2	RB-1	T5/S-1/QA	TB-2/QA	RB-1/QA	X	X	X	X
	4-8 ft bgs	T5/S-2	-	TB-2	RB-1	-	-	-	X	X	X	-
	8-12 ft bgs	T5/S-3	-	TB-2	-	-	-	-	X	-	-	-
T-11	6-8 ft bgs	T-11	-	TB-2	RB-1	-	-	-	X	X	X	X
T-14	6-8 ft bgs	T-14	-	TB-2	RB-2	-	-	-	X	X	X	X
T-23	2-4 ft bgs	T-23	-	TB-2	RB-2	-	-	-	X	X	X	X

Notes:
1. The spatial relationship of sample and blank numbers in the table is important. This design of the sample numbers themselves is not required. However, duplicate samples must be blind to the primary laboratory.
2. ER 1110-1-263 (1 Oct 90) does not require rinstate blanks for soil sampling activities, but allows for them if project specific considerations warrant.
3. This table should be prepared prior to field activities and included in the Sampling and Analysis Plan (SAP). The table prepared after field activities would document any deviation from the plan.

should include the rationale for the QC samples (how the data will be used), as well as the frequency for collecting QA and QC duplicates, matrix/matrix spike/matrix spike duplicates, equipment (rinsate) blanks, and trip blanks. This frequency may be expressed as a percentage of the total number of samples collected, or the QC samples may be identified by a specific sample location where a particular QC sample is warranted (e.g., the samples anticipated or noted as being most contaminated or associated with a particular background/upgradient area).

(b) Procedures. The subsections of the FSP that address each of the matrices to be sampled should include the proposed procedures for installation of equipment, field measurements, sample collection, sample homogenizing compositing and/or splitting, and decontamination. Field screening procedures, the screening criteria, and the required actions based on the screening criteria should be addressed. The specifications and requirements for field instrumentation, the initial and continuing calibration of the equipment, the schedule for calibration verification, as well as the requirements for field data evaluation and reporting must be outlined in the FSP. Table 3-4 is an example of a field instrument table that may be used on projects. Finally, each subsection should discuss the sampling procedures (charts, flow diagrams, or tables may be helpful in delineating the sampling program); a description of the containers, reagents, and procedures used for each matrix' sample collection, preservation, transport, and storage; a description of any filtration procedures or other techniques required during sample collection; any special conditions that are required for the preparation of sampling equipment or containers to avoid contamination; and notation of any time constraints or other difficulties with sending samples to the laboratory, including contingencies in the event of delays and/or slippage in the schedule. Additional information on field activity procedures is contained in the appendices. The following sections discuss the specific field activities of individual matrices.

(c) Geophysics. This section of the FSP should include discussion of the objectives of geophysical analysis and the techniques proposed to meet these objectives, and the general topics discussed in Section 3-3*c*(6), "Field activities." The discussion should include the rationale used to delineate the study area and determine the spacing of the geophysical measurements. The proposed equipment, equipment calibration, and quality control procedures; preliminary testing of the method employed and early termination procedures; reporting requirements; delineation of the area to be investigated; data processing; and interpretation of the data should also be included. Refer to other USACE guidance on this subject for the required information covering geophysical surveys.

(d) Soil gas survey. This section of the FSP should discuss the rationale for performing the soil gas survey, the rationale for selecting the location and frequency of soil gas samples, the equipment and methods used for drilling, the materials (casing, screen, etc., if required), installation methods, sampling methods, documentation requirements, and any of the general topics discussed in Section 3-3*c*(6).

(e) Groundwater. This section of the FSP should include a discussion of monitoring well location rationale (e.g., to determine groundwater flows, identify upgradient contaminant sources, etc.). Methods for monitoring well installation should also be discussed, including the following: obtaining water level and field measurements, required pumps, filters, equipment decontamination procedures, water disposal requirements; determining if free product is present, and aquifer testing. Additional language must also be presented within the FSP that discusses whether free product is anticipated and the effect that the free product may have on the sampling event. Refer to EM 1110-1-4000 for required information on installation of groundwater monitoring wells at HTRW sites. A discussion of whether field filtration of samples is to be implemented prior to preservation should also be included. Instructions C-2 and E-1 of this engineer manual, found in Appendices C and E, respectively, contain additional information on groundwater sampling and filtration techniques.

(f) Groundwater filtration. There are diverse views on the filtration of groundwater before sample preparation and analysis for metals. Options include: filter; not filter; and both. Results from filtered samples may best represent the concentration of metals being transported by groundwater flow. Results from unfiltered samples may be more of a function of well installation and development than groundwater contamination. The option selected should be based on the objectives of the specific project, use of the analytical data, comparability with previous site results, and the position of the regulators. Due to the fact that metals are digested from any soil particles present within the sample during analysis, metals concentrations may be higher for the unfiltered groundwater sample. Carbon dioxide may also exchange with oxygen prior to filtration, leading to metals precipitation. Therefore, delayed filtration may result in the precipitation of metals, which are then filtered, resulting in lower metals concentrations. For this reason, filtration of samples,

Table 3-4
Field Instrument Table

Instrument Manufacturer	Analyzer Name	Detector	Chemical Parameter[1]	Calibration Requirement[2]	Performance Checks[3]
- - -	- - -	PID	Total Ionizable Hydrocarbons	Daily	None
- - -	- - -	FID	VOC	Per measurement	Weekly
- - -	- - -	UV	SO_2	Weekly	Zero, Span, Drift, etc.
- - -	- - -	Foil	Dissolved O_2	Daily	Calibration Check

1 Compound, Analyte, or Detector Response
2 Calibrator Source, such as Hexane, Reference Material, etc.
3 Frequency of Zero, Span, Response Time, Calibration Check, etc.

if specified, should be performed shortly after collection. Field filtration procedures must be conducted prior to sample preservation, and both performed prior to sample shipment. An alternative procedure to filtering samples has proposed the use of a low-flow peristaltic pump during sample acquisition. Refer to EPA/540/4-89/001 and Heidlauf and Bartlett (1993) for additional information on this topic. Instruction E-1 found in Appendix E contains information on filtration techniques.

(g) Subsurface soil. This section of the FSP should discuss the rationale for boring locations, discrete and/or composite sampling, and any field analytical parameters to be measured. In addition, this section of the FSP should discuss drilling methods, logging procedures, sampling methods for physical and chemical analyses, and the general topics discussed in Section 3-3*c*(6). Documentation of soil boring information and descriptions is required. Additional information on subsurface soil sampling procedures is presented in Instruction C-6 located in Appendix C and in EM 1110-1-4000.

(h) Surface soil and sediment. This section of the FSP should discuss the rationale for the location and frequency of discrete and/or composite samples, all procedures required for collecting samples, and any applicable topics from Section 3-3*c*(6). Instructions C-5 and C-6 in Appendix C of this engineer manual contain additional information on sampling of sediments and surface soils.

(i) Surface water. This section of the FSP should discuss the rationale for the location and frequency of surface water samples, all procedures required for collecting surface water samples, and any applicable topics identified in Section 3-3*c*(6). Instruction C-3 of this engineer manual contains additional information on sampling surface water.

(j) Other matrices. This section of the FSP should discuss the rationale for the location and frequency of samples from other matrices and the general topics discussed in Section 3-3*c*(6). Examples of other matrices include perimeter air samples, process waste streams from particular points during a remedial action process, potable water supplies, bulk material, transformers, etc. Appendices C and D contain information on sampling other matrices.

(7) Sample chain-of-custody/documentation. This section of the FSP should describe appropriate sample custody/documentation procedures. Chain-of-custody procedures should always be used. Custody is divided into three areas: sample collection, laboratory, and final evidence files. Final evidence files include all originals of laboratory reports and should be maintained under documented control in a secured area. A sample or an evidence file is under custody if any of the following situations exist: the sample is in your possession; it is in your view after being in your possession; it was in your possession and you placed it in a secured area; or it is in a designated secured area. Any time requirements for maintaining chain of custody for samples, analytical data, and/or final evidence files should be identified. The USACE technical planners or the contractor may elect to establish documentation requirements that follow a more uniform organization than required by a field logbook. These documentation requirements would include the use of project forms. Any forms proposed for use should be task-specific, but may incorporate any of the topical requirements identified for the field logbook. All project forms must be presented in Appendix B of the project SAP. Alternative approaches to documentation may include the periodic submittal of documents along with the required submittal of the daily chemical quality control reports discussed in Section 3-3*d*(11) for desk audit purposes. Well installation diagrams, well development records, test pit logs, and drum log sheets are examples of such documentation. Additional information on documentation requirements is contained in Instruction F-1 in Appendix F.

(a) Field logbook. This section of the FSP should discuss the method for completing the logbook, making corrections, and the types of information to be included in the logbook. Sampling situations vary widely. No general rules can specify the exact information that must be entered in a logbook for a particular site. However, the logbook should contain sufficient information to enable the sampling activity to be reconstructed without relying on the collector's memory. Information recorded on other project documents; e.g., boring logs or well development forms should not be repeated in log books except in summary form, to avoid transcription errors. Logbooks should be kept in the field team member's possession or in a secure place during the field work. Following the site activities, the logbooks will become a part of the final evidence file. The following are some suggested topics to include in the logbook:

- Name and title of author, date, and time of entry.
- Purpose of sample activity.
- Name and address of field contact.

- Names and responsibilities of field crew members.
- Names and titles of any site visitors.
- Type of waste, suspected waste concentration if known, and sample matrix.
- Sample collection method.
- Number and volume of sample(s) taken.
- Location, description, and log of photographs (if taken) of the sampling points.
- References for all maps and photographs of the sampling site(s).
- Information concerning sampling changes, scheduling modifications, and change orders.
- Information concerning drilling decisions, not shown on the drill log.
- Information concerning access agreements.
- Details of the sampling location (dimensioned sketches of sampling locations may be appropriate).
- Date and time of collection.
- Field observations.
- Any field measurements made (e.g., pH, specific conductance, temperature, and water level depth).
- Sample identification number(s).
- Documentation of procedures for preparation of reagents or supplies that become an integral part of the sample (e.g., filters and absorbing reagents).
- Information from containers, labels of reagents used, de-ionized water used for blanks, etc.
- Sampling methodology, including distinction between grab and composite samples.
- Sample preservation.
- Sample distribution and transportation (e.g., name of the laboratory and courier).
- All sample documentation such as:
  - -- Bottle lot numbers as received from repository.
  - -- Chain-of-custody records numbers.
- Decontamination procedures.
- All documentation for investigation-derived wastes such as:
  - -- Contents and approximate volume of waste.
  - -- Disposal method.
  - -- Type and predicted level of contamination.
- Summary of daily tasks (including costs) and documentation on any cost or scope of work changes required by field conditions.
- Signature and date (entered by personnel responsible for observations).

(b) Photographs. This section of the FSP should describe how sampling points are to be marked and prepared for photographs. It should also discuss how photographs will be numbered and documented (i.e., photographic log).

(c) Sample numbering system. This section of the FSP should discuss the sample numbering system. A sample numbering system should be used to identify each sample for chemical analysis. The purpose of this numbering system is to provide a tracking system for retrieval of data on each sample. Sample identification numbers should be used on sample labels or tags, field sheets, sample tracking matrix forms, chain-of-custody records, and all other applicable documentation used during the sampling activity. A listing of all sample identification numbers should be maintained in the field logbook. QC samples should be disguised using the same numbering system selected for the field samples. An example of a sample numbering system is UAFB-92-SD-2-001.

Project Code	Year	Sample Type	Site No.	Sample No.
UAFB	92	SD	2	001

The sample identification number for sediment/soil, wipes, oil, surface water, and groundwater samples begins with the project code, followed by the year, the sample type, the site number, and the sample number. The project code in this case is UAFB, which stands for an unnamed Air Force base. The year is included to distinguish this sampling series from past sampling activities. The sample type describes the matrix of the sample, such as SS for a surface soil sample, SB for subsurface soil, SD for sediment, OL for oil, WP for wipe, GW for groundwater, and SW for surface water. The site number is the number that will identify the particular area on the base where sampling activities occurred. Finally, the sample number is added to the sample identification number. The sample identification number for subsurface soil samples, however, will vary somewhat. As with all samples, the sample identification number for subsurface soil samples begins with the project code through the sample number. Following the sample number, the final portion of this sample identification number will be the interval from which the sample was obtained. Therefore, a subsurface soil sample collected from an interval of 3 to 5 ft will be identified in the following manner:

Project Code	Year	Sample Type	Site No.	Sample No.	Interval
UAFB	92	SB	8	002	3-5

An alternate sample numbering system is explained in Appendix F-1.

(d) Sample documentation. This section of the FSP should discuss how each sample is to be documented in the permanent record. This section should include a discussion on sample labels or tags, sample field sheets, chain-of-custody records, custody seals, and cooler receipt forms. This section of the FSP should also present examples of these items.

(e) Documentation procedures. This section of the FSP should include a checklist of step-by-step procedures of how each sample is to be documented, i.e., filling out sample container air bills, chain-of-custody records, sample tracking matrices, etc.

(f) Corrections to documentation. This section of the FSP should discuss how changes are to be made on sample documentation forms.

(8) Sample packaging and shipping. This section of the FSP should include a discussion of sample packaging and shipping requirements; identification of all laboratories, including addresses and points of contact at the USACE QA laboratory and the contractor's laboratory; a schedule for submitting samples from the field; and defining of the mode of sample transportation (e.g., overnight courier). A checklist may be helpful for field personnel to verify completeness of sample shipment preparations. An example facsimile of a checklist for shipping HTRW samples is presented in Figure 3-2. In addition, it is advised that the receiving laboratories document the condition of field samples upon receipt at the laboratory. This enables verification of numerous items, including correct sample volumes, preservation applied, cooler temperature, etc.; chain of custody completeness and accuracy; and overall packaging techniques. A facsimile of such cooler receipt documentation is presented in Figure 3-3. Finally, another area where documentation is very beneficial is providing project-specific information along with field samples. The information may be used to define hazard categorization and/or disposal options. This documentation is suggested to accompany the QA samples that are sent to USACE's laboratory for the reasons stated above. A facsimile of the type of information needed for characterization and disposal of HTRW samples is presented in Figure 3-4. Additional information on sample packaging and shipping procedures is contained in Instruction F-2 in Appendix F.

(9) Investigation-derived wastes (IDW). This section of the FSP should discuss the procedures for collecting, labeling, storing, and disposing of the IDW. The procedures for assessing the related environmental samples and/or sampling the IDW to determine whether the IDW is hazardous should be explained. Finally, the discussion should address how the sample results will be evaluated to determine disposal options for the IDW. It is important to note in this section of the FSP that disposal actions must be conducted with the concurrence of appropriate USACE technical personnel and that the final decision on disposal must be agreed to by all parties.

(10) Contractor chemical quality control (CCQC). The contractor is required to ensure that quality is maintained throughout all field work by means of a three-phase control process (ER 1180-1-6, EP 715-1-2, CEGS 01450). CCQC phases (preparatory, initial, and follow-up) are performed onsite by the contractor whether or not a government representative is present. The contractor will summarize the activities of each CCQC phase

SHIPPING CONTAINER CHECKLIST SUMMARY

ATTN: Corps of Engineers Contractors

Failure to properly handle or document the project samples could jeopardize the usability of the sample results and ultimately the project. Prior to sending this cooler to the USACE Division Laboratory at the address shown below, please check the following items:

- Is the project clearly identified on the Chain-of-Custody (official project name, project location, project phase)? Is the United States Army Corps of Engineers project number from the Sampling Plan or Work Plan clearly indicated on the Chain-of-Custody?
- Are all enclosed sample containers clearly labelled with waterproof (permanent) ink?
- Are the desired analyses indicated on the bottle labels and Chain-of-Custody and are the metals defined on the Chain-of-Custody (e.g. metals = lead, cadmium, etc.)?
- Does the information on the Chain-of-Custody match the information on the sample container labels?
- Have you placed the Chain-of-Custody in a plastic bag and attached it to the inside of the cooler lid?
- Have the samples been properly preserved (acid or base and cooling to 4°C)?
- Is there a Contractor point of contact including name and phone number clearly shown on the Chain-of-Custody?
- Is there sufficient ice (double bagged in ziplocks) or "blue ice" in the cooler? It is recommended that the samples be prechilled before packing.

This is a partial list of the requirements for proper documentation and shipping of the environmental samples, please refer to the Work Plan or Sampling Plan for further details.

Figure 3-2. Shipping container checklist

COOLER RECEIPT

LIMS# _____

Contractor Cooler _____

QA Lab Cooler # _____

Number of Coolers _____

PROJECT: _____ Date received: _____

USE OTHER SIDE OF THIS FORM TO NOTE DETAILS CONCERNING CHECK-IN PROBLEMS.

A. PRELIMINARY EXAMINATION PHASE: Date cooler was opened: _____

by (print) _____ (sign) _____

1. Did cooler come with a shipping slip (air bill, etc.)? ..... YES NO

   If YES, enter carrier name & air bill number here: _____

2. Were custody seals on outside of cooler? ..... YES NO

   How many & where: _____, seal date: _____, seal name_____

3. Were custody seals unbroken and intact at the date and time of arrival? ..... YES NO

4. Did you screen samples for radioactivity using the Geiger Counter..... YES NO

5. Were custody papers sealed in a plastic bag & taped inside to the lid? ..... YES NO

6. Were custody papers filled out properly (ink, signed, etc.)? ..... YES NO

7. Did you sign custody papers in the appropriate place? ..... YES NO

8. Was project identifiable from custody papers? If YES, enter project name at the top of this form. YES NO

9. If required, was enough ice used? ..... Type of ice: _____ ..... YES NO

10. Have designated person initial here to acknowledge receipt of cooler: _____(date)_____

B. LOG-IN PHASE: Date samples were logged-in: _____

by (print) _____ (sign) _____

11. Describe type of packing in cooler: _____

12. Were all bottles sealed in separate plastic bags? ..... YES NO

13. Did all bottles arrive unbroken & were labels in good condition? ..... YES NO

14. Were all bottle labels complete (ID, date, time, signature, preservative, etc.)? ..... YES NO

15. Did all bottle labels agree with custody papers? ..... YES NO

16. Were correct containers used for the tests indicated? ..... YES NO

17. Were correct preservatives added to samples? ..... YES NO

18. Was a sufficient amount of sample sent for tests indicated? ..... YES NO

19. Were bubbles absent in VOA samples? If NO, list by GAS: _____ YES NO

20. Was the project manager called and status discussed? If YES, give details on the back of this form. YES NO

21. Who was called ? _____ By whom ? _____ (date)_____

Figure 3-3. Cooler receipt checklist

Characterization of Environmental Samples for Disposal

In order to properly dispose of samples, Federal and State Hazardous Waste Regulations require that the generator determine whether or not the sample is a hazardous waste. To assist the laboratory in making this determination, you are requested to answer the following questions concerning the site and respective contamination.

Instructions: Do not guess or hypothesize. Only provide answers that you can reasonably ascertain are accurate. If you do not know the answer, indicate in the blank that you do not know the answer by answering "Unknown". Please respond to all questions.

Site Name: _____

Address of Site: _____
_____

Sampling Date: _____

Sample Identification Number:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

1. *Indicate by sample identification number which samples are background samples (if none, write none):*

_____	_____	_____	_____
_____	_____	_____	_____

2. *Were unopened containers of chemicals found on site?* _____
Were unopened chemicals known to have been stored on site? ___
Is the contamination from this storage area? _____
List unused, unopened chemicals found at the storage site:

_____	_____
_____	_____
_____	_____
_____	_____

3. *Is the site a manufacturing facility?* _____
If yes, identify the industry: _____

Figure 3-4. Environmental sample characterization (Sheet 1 of 4)

Characterization of Environmental Samples for Disposal (Continued)

4. *Is the contamination at the site from the use of solvents?* ___
   If yes, identify the solvents: _____

5. *Is a process such as parts degreasing, electroplating etc. the suspected cause of the contamination?* _____
   If yes, identify the process: _____

6. *Do you suspect the sample to have any of the following contaminants? Circle all that you suspect.*

   Asbestos **PCBs** **Jet Fuel** **POL**

7. *What other contaminants do you expect to find in this sample?*

   _____ _____
   _____ _____
   _____ _____

8. *Briefly describe how this site was contaminated:* _____

   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

9. *Your Name:* _____ *Telephone:* _____

Thank You!

Figure 3-4. (Sheet 2 of 4)

Explanation of Characterization Questionnaire

Site Name: Indicate the name of the site where the samples were taken. For example, Fire Training Pit FTP 001, Landfill #10 Ft. Dix, etc.

Site Address: Write the address of the site.

Sampling Date: Indicate the date these samples were taken at the site.

Sample Identification Number: Identify each sample. This number in most cases should be the same as the identification number on the chain of custody form. Each sample should have a unique number. Be sure to identify each sample.

Question number 1 will assist us in segregating potentially clean samples - the background samples from the contaminated samples.

Question number 2 has been asked to determine whether the sample would be P or U-listed. If the sample is contaminated with a commercial chemical product or an off-specification chemical, the chemical itself would be P-listed or U-listed. This chemical would have to be a virgin chemical, i.e. a chemical that was manufactured, however it had not yet been used for its intended purpose. For example, if the just manufactured chemicals were all stored on a particular concrete pad, and analysis of the pad showed trace amounts of that chemical, then the pad would be considered a P or U-listed waste. Once the listed waste contaminated the soil or water, the entire mixture would also become P or U-listed.

Question number 3 will help us to identify whether the waste is K-listed. If the manufacturing process can be defined, the sample may be considered to be waste from a process listed on the K-list. If for example you are investigating a landfill and you know that the waste in the landfill came from a certain manufacturing process, that waste may also be K-listed as well as the contaminated soil and water.

Question number 4 will assist us in determining if the sample contains a F-listed waste.

Question number 5 will assist us in determining if the sample contains a K or F-listed waste. If the answer to the question is yes, then we will check to see if that process has been identified on the K or F-list.

Question number 6 will assist us in identifying any other contaminants that may require that special handling provisions be employed during disposal.

Figure 3-4. (Sheet 3 of 4)

Explanation of Characterization Questionnaire
(Continued)

Question number 7 requests that you identify any contaminants you may expect to find in the sample that would impact the characterization of the sample as a RCRA hazardous waste.

Question number 8 asks you to describe how t... site was contaminated. Identify any processes or procedures which led to the resultant contamination.

Question number 9 asks for your name and telephone number. If we have questions concerning the information on this form, we will contact you.

Figure 3-4. (Sheet 4 of 4)

in the daily chemical quality control report (DCQCR). The CCQC phases are performed for each definable feature of work. A definable feature is a task that is separate and distinct from other tasks and has separate control requirements. For example, the definable features of the sample collection task include, at a minimum, each matrix (air, water, soil, containerized waste, etc.). This section of the FSP should contain the contractor's detailed plans for implementing the CCQC phases, including: identification of the CQC representative; listing of field equipment; description of activities during the phases; identification of the definable features of work; and generation of a sample table that will be used to match up primary and QA samples. Instruction H-1 in Appendix H contains an example of the table and checklists to help plan the preparatory and initial phases.

(a) Preparatory phase. The CQC representative, in conjunction with the contractor's sampling team, will conduct the preparatory phase prior to beginning any definable feature of the work. It includes a review of all work requirements; a physical examination of all required materials and equipment; an examination of work areas to ascertain completion of all preliminary work; and a demonstration of all field activities. If new sampling or technical personnel arrive onsite during the work effort, the CQC representative must repeat this phase before new personnel begin work.

(b) Initial phase. The CQC representative is responsible for overseeing every step of the definable feature of work when that work is first initiated.

(c) Follow-up phase. The CQC representative is responsible for continued daily contract compliance until completion of the particular feature of work.

(11) Daily chemical quality control reports (DCQCR). During the field investigation or remedial action activities, DCQCRs will be prepared daily, dated, signed by the CQC representative, and sent to USACE at a rate specified in the scope of work (SOW) or specifications. The contents of the DCQCRs may be incorporated into the Daily Contractor Quality Control (CQC) reports required by ER 1180-1-6, Construction Quality Management, May 16, 1988. With respect to geotechnical and chemical procedures, these reports should include weather information at the time of sampling, field instrument measurements, calibrations, departures from the approved SAP, deviation from approved geotechnical procedures (such as well installation or drilling), problems, and instructions from government personnel. Any deviations that may affect DQOs must be conveyed to USACE personnel (technical manager, project chemist, etc.) immediately. The following should be attached to the DCQCRs: quality assurance sample tables that match up primary and QA samples (see Table H-1 in Appendix H),

copies of chain-of-custody forms, field-generated analytical results, and any other project forms that are generated. This section of the FSP should summarize how the DCQCRs will be prepared. If the contractor intends to use a report form, a sample of this form should be included. Project-specific DCQCR requirements, as noted in the SOW or specifications, should also be included in this section of the FSP.

(12) Corrective action. The FSP should include corrective action procedures to be taken in the event a discrepancy is discovered by field personnel, or during a desk or field audit, and/or the laboratory discovers discrepancies or problems. Typical discrepancies or problems include, but are not limited to: improper sampling procedures, improper instrument calibration procedures, improper sample preservation, problems with samples upon receipt at the laboratory, etc.

(13) Project schedule. This section of the FSP should include an outline of the schedule based on client and regulator requirements. Listed items should include: project plan review periods, easement/permit periods, fieldwork, sample analysis, data management and validation, and investigation report writing.

(14) Sampling apparatus and field instrumentation. For in-house USACE projects, this section of the FSP should contain a list of the field equipment that will be required to perform the field activities. For contracted projects this list will be presented as part of the plan for conducting the preparatory phase of CCQC (see Section 3-3*c*(10)(a)).

d. Quality Assurance Project Plan. The following section briefly describes the minimum requirements of a QAPP.

(1) Title page. The title page should include the name of the document, (e.g., Phase I Remedial Investigation Quality Assurance Project Plan) and the date it was prepared. The contractor's laboratory QA manager or director should sign the title page if analytical services are provided. This will ensure that the laboratory is aware of the requirements for precision, accuracy, representativeness, completeness, comparability, and sensitivity.

(2) Table of contents. The table of contents should include a listing of the QAPP elements, any appendices that are required to augment the QAPP, and figures and tables. The end of the table of contents should include a list of the recipients of official copies of the QAPP.

(3) Project description. The project description should consist of a general paragraph describing the scope of the work, general objectives, and the measurements of the investigation. If the project description is discussed in the Project Work Plan or Field Sampling Plan, it does not need to be repeated in the QAPP, but it should be incorporated by reference.

(4) Project organization and responsibilities. This element of the QAPP identifies key laboratory personnel or organizations that are necessary for each analytical activity during the study. A table or chart showing the organization and lines of authority should be included. When specific personnel cannot be identified, the organization with the responsibility should be listed. The organizational chart should also include all subcontractors and their key points of contact. Separate organizational charts for subcontractors may also be needed. The organizational chart should identify QA managers, including those of subcontractors, and should illustrate their relationship to other project personnel. The QA managers should be organizationally independent of project management so that the risk of conflict of interest is minimized. An organizational chart is recommended as a figure. Requirements for the contractor's laboratory and laboratory personnel are located in Section B-3 of Appendix B. This section of the QAPP should also describe the responsibilities of all project participants, including QA managers. The responsibility for each type of analysis, physical measurement, and process measurement should be indicated.

(5) Quality assurance objectives. This section should describe the QA objectives for the data, so that the data can achieve their intended use. Use of boiler-plate language (i.e., simply listing precision, accuracy, representativeness, completeness, and comparability (PARCC) parameter definitions) should be avoided in this section.

(a) Background. This section should highlight project-specific data needs that have been identified for the project, short-term decisions that will be made during the project planning phase, and long-term decisions that will be made prior to project closeout. A brief summary of the type of samples and analyses that will be required to meet the data needs should also be included in this section. Section B-4*a* of Appendix B contains a discussion of the background information that should be included in this section of the QAPP.

(b) QA objectives for chemical data measurement. Definitions of the PARCC terms and details concerning

these terms that must be investigated and identified in the QAPP are located in Sections B-4*b* and B-4*c* (and Section 9.0 to a lesser extent) of Appendix B. For individual matrix groups and parameters, a cooperative effort should be undertaken by USACE, the lead agency, the contractor, and the laboratory staff to define what levels of quality should be required for the data. Precision and accuracy quantitative goals must be established for chemical/physical measurements. Completeness goals may also be expressed quantitatively for individual samples (i.e., critical samples) or for the work effort as a whole. The remaining parameters of representativeness and comparability are assessed qualitatively (See Appendix B for further information). Sensitivity requirements are also addressed in detail in Appendix B. These QA objectives will be based on a common understanding of the intended use of the data, available laboratory procedures, and available resources. However, QA objectives should be defined in terms of project requirements, not in terms of the capabilities of the test methods. The reason for this is that many testing methods do not express precision and accuracy requirements, and therefore reliance on this approach may not always have a foundation. In addition, sensitivity (detection limits) expressed within a method is based upon reagent water matrix and may not be achievable within an environmental matrix. For these reasons, familiarization with methods that express multi-laboratory precision and accuracy ranges and method detection limits will assist in defining what may be accomplished for a parameter. However, when defining the requirements for the project, the quality requirements established by the data user, the complexity of the media to be analyzed, the potential for interferences, etc., must be considered. In addition, due to the limited applications where EPA standard methods are mandatory, these goals must be specified directly within the QAPP. If QA objectives exceed the capabilities of available methods, either the methods or test plan must compensate for these deficiencies. The section on analytical methods requires a familiarity with regulatory requirements concerning data usage. Any applicable regulations that mandate the use of certain methods for any of the sample matrices and parameters listed in the project description should be specified. All project required blanks, QA/QC duplicates, matrix spikes/matrix spike duplicates, etc. to be collected for assessment of QA objectives should be itemized for the matrix groups identified in Section 3-3*c*(6) of this manual. Because precision and accuracy can be measured in various ways, the method to be used should be explained. This discussion should address whether precision is being applied to field activities, thereby requiring duplicates to be taken in the field; or whether precision is to assess only the laboratory performance by requiring a duplicate analysis from the same sample. Separate precision goals should be established for each of these situations. All such information should be summarized in either text or tabular format. An example is presented in Table 3-5. The following statements are examples of descriptions for precision, accuracy, and completeness:

- Precision objectives for all the listed methods except pH are presented as relative percent difference (RPD) of field duplicates. Precision objectives for pH are listed in pH units and expressed as limits for field duplicates.

- Precision objectives for unconfined compressive strength are given as relative standard deviation for triplicate sets.

- Accuracy objectives for organic compounds are given as percent recovery range of surrogate compounds, and laboratory matrix spikes. Accuracy objectives for temperature measurements are absolute deviations in degrees Celsius.

- Completeness is defined as the number of measurements judged valid compared to the number of measurements needed to achieve a specified level of confidence in decision making. It has been estimated that 10 valid measurements should suffice to demonstrate that the arsenic concentration in the discharge is less than 50 ug/L at a confidence level of 90 percent. To allow for a margin of error in the estimated number of samples, 15 valid measurements are planned, resulting in a completeness objective of 150 percent. An additional six spare samples will be completed but will not be analyzed, unless needed to achieve the desired confidence level.

(6) Sampling locations and procedures. This section of the QAPP should reference the sections of the FSP that discuss the general rationale for choosing sampling locations and the sampling procedures proposed for each matrix.

(7) Sample custody and holding times. This section of the QAPP should reference the appropriate sections (sample custody/documentation) of the FSP for requirements in the field work. All custody and holding requirements pertaining to the laboratory activities must be addressed within this section.

Table 3-5
Example QA Objectives Summary

Data Use	Matrix	Sample Type	Analytical Method	Number of Field of Samples	Number of Field QC Samples	Analytical Level	Precision (RPD[1]) Field Dups	Precision (RPD[1]) Lab Dups	Laboratory Accuracy (Matrix Spikes)[2]	Sensitivity	Completeness
Screening of soils for stockpile separation and confir- mation of extent of excavation	Excavated Soil	Discrete	Petroleum Immuno-Assay Test Kit	As required for screening	NA	Level I	NA	NA	NA	100 mg/kg (ppm) (estimate)	100%
Confirmation of extent of excavation (tank pits and pipe trenches	Tank Pit Soil	Discrete	EPA - 8240 Volatile Organics	6	1 Trip Blank/Day 1 Field Duplicate for every 10 samples	Level III	< 50 RPD	< 25 RPD	approx. 0-140 % Recovery (compound specific)[2]	5 to 10 µg/kg (ppb) (compound specific)[2]	90%
	Tank Pit Soil	Composite	EPA - 8270 Semivolatile Organics	16	1 Field Duplicate for every 10 samples	Level III	< 50 RPD	< 35 RPD	approx. 30-140 % Recovery (compound specific)[2]	660 to 5300 µg/kg (ppb) (compound specific)[2]	90%
	Pipe Trench Soil	Composite		1							
	Tank Pit Soil	Composite	EPA - 8080 Pesticides	16	1 Field Duplicate for every 10 samples	Level III	< 50 RPD	< 35 RPD	approx. 35-135 % Recovery (compound specific)[2]	3 to 120 µg/kg (ppb) (compound specific)[2]	85%
	Pipe Trench Soil	Composite		1							
	Tank Pit Soil	Composite	EPA - 7421 Total Lead	16	1 Field Duplicate for every 10 samples	Level III	< 35 RPD	< 20 RPD	75-125% Recovery	1.0 mg/kg (ppm)	90%
	Pipe Trench Soil	Composite		1							

[1] RPD = Relative Percent Difference.
[2] Refer to analytical method for compound specific limits.

(8) Analytical procedures. This section of the QAPP identifies the appropriate analytical test methods that should be used for each environmental sample. The applicability of an individual method will be dependent upon the regulatory authority the project is being performed under, as well as the level of data quality required to support the data needs and decisions of the project. Analytical instructions are presented in Appendix G of this manual.

(9) Calibration procedures and frequencies. This section of the QAPP discusses the calibration procedures that are used by the contractor's laboratory. Issues that should be addressed in this section include defining the number and concentration of calibration standards to be used, the calibration range, and the procedures used to establish and verify the calibration of the laboratory's instruments. Further information on calibration procedures is presented in Section B-7 of Appendix B.

(10) Internal QC checks. This section of the QAPP identifies the specific internal QC methods used by the laboratory performing the analytical tests. Type and frequency of specific QC samples performed by the laboratory are dependent upon the specified analytical method. Internal QC methods require performance on a sample batch basis and include analyses of method blanks, laboratory control samples, and actual environmental samples as duplicates, matrix spikes, and matrix spike duplicates. A more detailed discussion of internal QC procedures is presented in Section B-8 of Appendix B.

(11) Calculation of data quality indicators. This section of the QAPP should discuss how precision, accuracy, and completeness goals are to be calculated from the project data. A more detailed discussion of the methods used to calculate these data quality indicators is presented in Section B-9 of Appendix B.

(12) Corrective actions. This section of the QAPP addresses corrective actions that must be implemented if laboratory QA specifications are not met. The QAPP should discuss corrective action procedures that will be implemented if problems are observed with incoming samples, sample holding times, instrument calibration procedures, specified practical quantitation limits, or internal QC samples. Corrective actions may include resampling, reanalyzing samples, or auditing laboratory procedures. The QAPP should identify persons responsible for initiating these actions. It should also contain procedures for identifying and documenting corrective actions and procedures for reporting and follow-up of corrective actions. A more detailed discussion of corrective action procedures is contained in Section B-10 of Appendix B.

(13) Data reduction, review, validation, and reporting. This section of the QAPP discusses the data review process that is required to assure the validity of the data. This process may include a combination of individual data reduction, review, validation, and reporting procedures. Data reduction procedures must be summarized and the persons responsible for data reduction must be identified. The data review process should be discussed. Procedures for an independent validation of the data, if required, should be discussed. Finally, the format for reporting the data and the data reporting schedule should be specified. For comprehensive projects that involve a substantial number of samples, or projects that require continued monitoring, the use of interim data deliverables for reporting is recommended. These deliverables should be submitted after a proposed milestone instead of at the project completion. A detailed discussion of data reduction, review, validation, and reporting requirements is presented in Section B-11 of Appendix B.

(14) Preventive maintenance. This section of the QAPP should discuss the laboratory's preventive maintenance plan that will be implemented to minimize downtime of laboratory instruments. Preventative maintenance requirements are discussed in Section B-12 of Appendix B.

(15) Performance/system audits. This section of the QAPP describes the performance and systems audits that will be performed onsite and at the contractor's laboratory. Performance and system audits are discussed in Section B-13 of Appendix B.

(16) QC reports to management. This section of the QAPP discusses QC reports that are submitted by the laboratory to the contractor and USACE. These reports typically include an assessment of accuracy, precision, and completeness; performance and system audit results; and significant QA problems encountered. This section of the QAPP should identify the individual responsible for preparing the QC reports and the type and frequency of the reports.

e. Appendices. The appendices should contain things such as references, standard forms, and a list of abbreviations and acronyms.

Chapter 4
Sampling and Analysis Protocols

4-1. General

This section of the engineering manual provides guidance to USACE personnel and USACE contractors for using the sampling and analytical instructions in the appendices and developing project-specific instructions if project-specific characteristics make it impractical to use the sampling and analytical instructions found in the appendices. Issues other than those identified in the general SAP format requirements found in Chapter 3 may have to be included in the SAP to meet project-specific regulatory requirements. To meet project-specific protocols and satisfy any additional requirements, additional field and analytical SOPs and references have been included in Appendix A. General guidance for developing additional site-specific instructions has been included in this chapter. With respect to sampling and analytical protocols, the information provided in this section may be used to prepare the scope of work for the project or to prepare the SAP. In some instances, data collection activities will occur that are not covered by this engineering manual. The references in Appendix A and the discussion in Section 4-4 may be useful under these circumstances.

4-2. Selecting Sampling and Analytical Instructions

As discussed in Section 2-3, selection of sampling and analytical protocols for a specific site is dependent upon the site constraints, data needs and data quality objectives, and sampling strategies for the various media. After an analysis of these factors has been completed, sufficient information should exist to select appropriate sampling and analytical instructions from the appendices in this manual. As discussed in Section 2-3, instructions should be selected after consideration of the following criteria: schedule, regulatory, technical (effectiveness and implementability), and budget. The following sections provide guidance to use during the selection process.

a. Sampling instructions. Information gathered from Steps 1 through 3 discussed in Section 2-3 should be used to identify applicable sampling protocols from the instructions in the appendices. An analysis of the constraints at the site will provide information needed to propose sampling locations and sampling procedures. This analysis should consider the media to be sampled, the types of contaminants, and the hydrology of the site. Project resource constraints will also be a factor. An analysis of data needs and data quality objectives will identify filtration, compositing, and homogenization requirements, if applicable, and field QC requirements. Sampling strategies should also be reviewed to determine the location and frequency of samples. After this information has been reviewed, appropriate sampling method options may be developed from the instructions in the appendices. If the instructions in the appendices do not contain an appropriate sampling method, alternative methods may be developed using the references in Appendix A and the procedures described in Section 4-4.

b. Analytical instructions. The information needed to properly select an analytical instruction can be obtained from following Steps 1, 2, and 3 of Section 2-3. Analysis of the constraints at the site (Step 1) provides information about the sample matrix, measurement parameters, and regulatory and customer preferences in regard to the type of analytical method to be used. A review of the data needs (Step 2) will define grab/composite procedures, decontamination procedure requirements, sample container requirements, preservation requirements, QC requirements, filtration requirements, homogenization and sub-sampling requirements, detection limit requirements, instrumentation requirements, and appropriate analytical methods. After this information has been reviewed, appropriate analytical options may be identified from the instructions in Appendix G. If the instructions identified in Appendix G do not contain an appropriate analytical method, the references in Appendix A and the procedures in Section 4-4 may be used to develop additional instructions.

4-3. Additional Standard Operating Procedures

If the appendices do not contain appropriate sampling and analytical protocols, it will be necessary to develop additional instructions. Sections 2-3 and 4-2 of this manual should be consulted when deciding if other instructions need to be developed. An example of a situation that would require preparation of a new instruction is the spring sampling scenario discussed in Step 2 of Section 2-3 of this engineering manual. Section 4-4 of this engineering manual discusses the methodology for developing instructions. The references in Appendix A contain information that may be used to develop additional instructions.

4-4. Development of Project-Specific Protocols

As previously discussed, it may be necessary to develop sampling and analytical protocols other than those identified in the appendices. Additional instructions may be required for a myriad of reasons: client preferences,

regulators' preferences, unusual site conditions, budget considerations, etc. Before developing new instructions, it is important to perform Steps 1 through 4 of Section 2-3. If, after performing these four steps, it is determined that new sampling and analytical protocols need to be developed, or protocols other than those found in the appendices are preferred, then this section and the references in Appendix A can be used to develop the new protocols. However, it is important that the new instructions be able to satisfy data needs and data quality objectives as well as satisfying scheduling, regulatory, technical, and budget criteria. The following two subsections provide guidance for developing new instructions. Additional information can be found in several of the guidance documents listed in Appendix A, especially EPA/600/2-80/018, EPA 600/4-79-020, SW-846, and EPA/540/P-87/001.

a. Sampling instructions. Below is a template that may be used as an outline to develop new sampling instructions. The references in Appendix A provide additional guidance.

(1) Scope and purpose.

(2) Definitions.

(3) Applicability.

(4) Sample locations.

(5) Applicable sampling strategies (grab/composite: random, judgmental, stratified, etc.).

(6) Identify when filtration is applicable (sampling for dissolved metals).

(7) Identify when homogenization is applicable (sampling solid media).

(8) Method specified in entirety (step-by-step presentation).

(9) Field QC requirements (all field duplicates, all QA splits, volatile organic analysis/water-trip blanks, soils background samples, highly contaminated media rinsates).

(10) Section highlighting split sample techniques/ deviations from normal protocol.

(11) Preservation techniques (cool, acid preservation, base preservation, chlorine binding).

(12) Field measurements.

(13) Miscellaneous considerations.

b. Analytical instructions. Below is a template that may be used as an outline to develop new analytical instructions. The references in Appendix A provide additional guidance.

(1) Scope and purpose.

(2) Definitions.

(3) Applicability to matrices.

(4) Applicability to grab/composite procedures.

(5) Decontamination procedure requirements.

(6) Sample container requirements.

(7) Preservation requirements.

(8) Special QC requirements (second column confirmation, additional surrogate/spike/internal standards run, extra blanks, etc.).

(9) Identify when filtration is applicable (dissolved metals).

(10) Identify when homogenization is applicable (total recoverable petroleum hydrocarbons, metals).

(11) Table of applicable methods.

(12) Method detection limits and/or practical quantitation limits.

(13) Precision and accuracy criteria.

(14) Instrumentation requirements.

(15) Analyst experience requirements.

(16) Sample preparation (cleanup procedures).

(17) Miscellaneous considerations.

Appendix A
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Appendix B
Chemical Analysis Requirements

B-1. Objective

The chemical analysis requirements and analytical instructions presented in Appendix G shall serve U.S. Army Corps of Engineers (USACE) or contracted personnel during the generation of the sampling and analysis plan (SAP) with the specification of the technical requirements involved with the chemical analysis to support USACE hazardous, toxic, and radioactive waste (HTRW) Program Sampling and Analytical Activities. The overall objective is to obtain technically valid and legally defensible environmental data which will meet or exceed the required project-specific data quality objectives (DQOs). This appendix will describe in detail the minimal management policies, objectives, principles, and procedures which will be used in conjunction with section 3.0, "Sampling and Analysis Plan - Format and Contents," to generate data of the required quality. The level of data quality achieved with this approach is expected to be III+.

B-2. Applicability

Chemical analysis requirements provide specifications, definitions, policies, and numerous interpretations associated with the generation of chemical data. Analytical methods, including preparatory, digestion, extraction, and analytical methods are presented as individual instructions in Appendix G of this document by testing parameter. Instructions applicable to a project are to be used in conjunction with the requirements established here, to detail the contractor requirements for chemical analyses. The following chemical analysis requirements are formatted in the same fashion as the quality assurance project plan (QAPP) portion of Table 3-1, for ease of incorporation within the project SAP (QAPP). The parameter specific instructions present potentially pertinent standard Environmental Protection Agency (EPA) methods, and their general applicability toward analysis of samples. The instructions should be reviewed with each particular method's requirements being evaluated for applicability toward a project based upon data needs and the required level of quality of that data. The required level of quality control (QC) may also be modified (more or less stringent) based upon project requirements. The chemical analysis requirements and subsequent parameter-specific instructions outline the minimum required laboratory QC samples only as outlined by the method references, and does not address the field QC sample requirements. Any deviations to the established methodologies must be documented thoroughly within the SAP, and be agreed to by the USACE COR. These requirements and parameter-specific instructions may be used as written to achieve the data level III+, or modified based upon project requirements. In addition, **bold type** is utilized throughout these instructions to cue input based upon project-specific requirements and to clarify USACE policy. All decisions and information gathered that clarify or modify the topics identified within must be summarized thoroughly within the project SAP. Definitions for key words used in these instructions may be referenced from appendix J of this guidance document.

B-3. Project Organization and Responsibilities

a. Contract laboratory requirements. All Contract Laboratory(ies) are required to undergo a USACE validation as outlined in ER 1110-1-263. This validation encompasses the analyses of performance audit samples and an onsite inspection; and must be completed before a contract laboratory can provide any analytical support for a USACE HTRW project.

b. Analytical personnel responsibilities and experience requirement. The Contract Laboratory must have an organization with well-defined responsibilities for each individual in the management system to ensure that sufficient resources are available to maintain a successful operation. The adequacy of the facilities and equipment is as important as the technical staff to accomplish the work required.

(1) Contract laboratory management. Contract Laboratory Management shall be responsible for actively supporting the implementation of the laboratory's Quality Management Manual within the laboratory, maintaining accurate standard operating procedures and enforcing their use in the laboratory, maintaining a work environment that emphasizes the importance of data quality and providing appropriate management support.

(2) Laboratory quality assurance officer. A Laboratory Quality Assurance Officer shall be responsible for overseeing the quality assurance aspects of the data and reporting directly to upper management to meet all of the terms and conditions of the project or instruction(s). This individual shall have a minimum of a Bachelor's degree in chemistry or any related scientific/engineering discipline. A minimum of 3 years of laboratory experience, including at least 1 year of applied experience with quality assurance (QA) principles and practices in an analytical laboratory, shall be required.

(3) Organic chemistry section. The Contract Laboratory shall maintain an Organic Chemistry Section with appropriate personnel, facilities, and instrumentation to conduct the work required. The following disciplines must be clearly represented and staffed.

(a) Organic Section Supervisor(s). The gas chromatograph/mass spectrometer (GC/MS), GC, and/or Sample Preparation Laboratory Supervisor(s) are responsible for all technical efforts of their respective laboratories to meet all terms and conditions expressed for each project. These individuals shall have a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline. A minimum of 3 years of laboratory experience, including at least 1 year of supervisory experience, shall be required.

(b) GC/MS operator. Qualifications for these individuals shall be at a minimum of 1 year of experience in operating and maintaining GC/MS/DS with a bachelor's degree in chemistry or in any related scientific/engineering discipline, or in lieu of the bachelor's degree, 3 years of experience in operating and maintaining the GC/MS and interpreting GC/MS data.

(c) Mass spectral interpretation specialist. Qualifications for these individuals shall be at a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline and a training course(s) in mass spectral interpretation. These individuals shall also have a minimum of 2 years of experience in mass spectral interpretation.

(d) GC High Performance Liquid Chromatography (HPLC) operator(s). Qualifications for these individuals shall be at a minimum of 1 year of experience in operating and maintaining GC/HPLC equipment, respectively, with a bachelor's degree in chemistry or a related scientific/engineering discipline, or in lieu of the bachelor's degree, 3 years of experience in operating and maintaining the GC/HPLC and interpreting GC/HPLC data.

(e) Pesticide residue analyst. The pesticide residue analyst and other chromatographic analysis expert qualifications. These individuals shall have a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline. These individuals shall also have a minimum of 2 years of experience in operating and maintaining chromatographic instruments and interpreting chromatograms.

(f) Extraction/concentration specialist. Qualifications for these individuals shall be at a minimum of a high school diploma and a college level course in general chemistry. These individuals shall also have a minimum of 1 year of experience in extraction/concentration.

(g) Technical staff backup. The Contract Laboratory shall have a minimum of one chemist available at any one time as a backup technical person with similar qualifications for each analysis they are backing up, to ensure continuous operations and accomplish the required work. These individuals shall have a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline.

(4) Inorganic chemistry section. The Contract Laboratory shall maintain an Inorganic Chemistry Section with the appropriate personnel, facilities, and instrumentation to conduct the work required for each project. The following disciplines must be clearly represented and staffed:

(a) Inorganic section supervisor(s). The metals, wet chemistry, and/or sample preparation laboratory supervisor(s) are responsible for all technical efforts of their respective laboratories to meet all the terms and conditions for each project. These individuals shall have a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline. A minimum of 3 years of laboratory experience, including at least 1 year of supervisory experience, shall be required.

(b) Inductively Coupled Argon Plasma Emission Spectroscopy (ICAP) Spectroscopist. Qualifications of these individuals shall be at a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline and specialized training in inductively coupled plasma (ICP) spectroscopy. These individuals shall also have a minimum of 2 years of applied experience with ICP analysis of environmental samples.

(c) ICAP operator. Qualifications for these individuals shall be at a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline with 1 year of experience in operating and maintaining ICP instrumentation, or, in lieu of the educational requirement, 3 additional years of experience in operating and maintaining ICP instrumentation.

(d) Atomic absorption (AA) operator. Qualifications of these individuals shall be at a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline with 1 year of experience in operating and maintaining AA instrumentation for graphite furnace, flame, and cold vapor AA, or, in lieu of the educational requirement, 3 additional years of experience in operating

and maintaining AA instrumentation, including graphite furnace, flame, and cold vapor techniques.

(e) Inorganic sample preparation specialist. Qualifications for these individuals shall be at a minimum of a high school diploma and a college level course in general chemistry or equivalent. These individuals shall also have a minimum of 1 year of experience in sample preparation in an analytical laboratory.

(f) Technical staff backup. The Contract Laboratory shall have a minimum of one chemist available at any one time as a backup technical person with similar qualifications for each analysis they are backing up, to ensure continuous operations and accomplish the required work. These individuals shall have a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline.

(5) Classical Techniques Analyst. Qualifications of these individuals shall be at a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline. These individuals shall also have a minimum of 1 year of experience with classical chemistry laboratory procedures, in conjunction with the education qualifications, or, in lieu of the educational requirement, 2 years of additional equivalent experience.

(6) Technical Staff Backup. The Contract Laboratory shall have a minimum of one chemist available at any one time as a backup technical person with similar qualifications, to ensure continuous operations and accomplish the work required. These individuals shall have a minimum of a bachelor's degree in chemistry or any related scientific/engineering discipline.

(7) Sample Custodian and Data Management. The Contract Laboratory shall also maintain and staff positions for Sample Custodian and Data Management personnel.

B-4. Quality Assurance Objectives

a. Background. To generate data that will meet the contract objectives, it is necessary to define the types of decisions that will be made and identify the intended use of the data. Data Quality Objectives are defined as an integrated set of thought processes which define data quality requirements based on the intended use of the data. Data Quality Objectives are necessary in obtaining sufficient data of known defensible quality for the intended use. The DQO process will assist in determining the appropriate sample handling procedures, analytical methods, precision, accuracy, representativeness, completeness, and comparability (PARCC) parameter requirements, and practical quantitation limits. In the generation of the SAP, whether this is done by contractor or USACE personnel, a number of steps must occur at the planning stages for each project phase by various technical disciplines, in order to identify all necessary data needs to complete the project close out. Each phase will have different information requirements and therefore different data needs at these particular stages of the project life. However, the project life as a whole must be kept in mind to optimize each phase and avoid repetitive sampling and analytical work efforts. These planning exercises will then lead to a comprehensive sampling and analytical protocol for each phase. These tasks may be performed by USACE for work done in-house or prescribed for a contractor within a Scope of Work; or this may be accomplished by the contractor and developed directly into the SAP. The use of HTRW technical project planning guidance in development of these goals or objectives for data collection design is strongly encouraged.

(1) General assessment of data needs. Data needs are determined for the project based upon the eventual decisions which need to be made. At this same time, a determination of the data quality required for each piece of data (data need) is also defined by the eventual data user. This information, whether given as quantitative uncertainties or a qualitative assessment of requirements, will help the other technical planners (data implementors) to identify applicable sampling and analytical protocols to generate the required data. In order to accomplish this, all data needs should be compiled and grouped by location, matrix, and parameter. Once the grouping is completed, the data quality requirements of these needs are assessed by analytical parameter (per matrix, per area). It is possible to have more than one data user requesting the same analytical parameter for a particular area's media. In those cases, the most stringent data user requirements are utilized to ensure the usability of this data by all requesting parties. This information is then used to decide the analytical level and appropriate sampling and analytical methods to propose for collecting of the required data.

(2) General assessment of data collection options. **Initially, the applicability of field methods to the objectives of the project should be investigated.** These may be used in conjunction with or without more comprehensive laboratory analytical methods. Field methods include qualitative or semi-quantitative field screening techniques (e.g., photoionization detector/flame ionization detector (PID/FID), immuno-assay, or colorimetric screening),

quantitative onsite instrumentation (x-ray fluorescence (XRF), gas chromatography (GC), gas chromatography/ mass spectrometry (GC/MS)), etc. In addition to field methods, **standard analytical methods must also be reviewed for applicability to the project.** Decisions may include defining the need or type of confirmation necessary (e.g., GC versus GC/MS), whether particular methods are dictated by the data user (e.g., outlined by regulatory authority), or whether there are particular sensitivity, precision, accuracy, or completeness goals which must be attained. All of these project-specific objectives help define the potential applicability of various analytical methods.

b. Measurement objectives. Once the applicable analytical methods are identified, QA objectives for the measurement through the assignment of appropriate PARCC parameters (precision, accuracy, representativeness, comparability, and completeness) and sensitivity (practical quantitation limits) is done. These requirements must be specified for each analytical method planned to establish the standard criteria to which the resulting project data are reviewed to assess contract compliance. Full PARCC parameter evaluation is a routine aspect of data review, validation, and defining usability of the data at the completion of a work effort. In order to ensure that quality data are continuously produced during analysis, and allow the eventual compliance review, systematic checks must show that test results remain reproducible and that the analytical method is actually measuring the quantity of target analytes in each sample without unacceptable bias. The reliability and credibility of analytical laboratory results can be corroborated by the inclusion of a program of scheduled analyses of replicates, standards, surrogates, and/or spiked samples. This program of scheduled laboratory QC may be viewed from two aspects; both batch and matrix-specific QC procedures.

(1) Batch QC procedures. Batch QC may be viewed as those QC procedures included to ensure the analytical method is being performed in an in-control mode of operation. This would encompass the inclusion and results of any blanks, laboratory control samples, blank spikes, QC check standards, PA samples, etc. These procedures lack any information on how well the method is performing with respect to the project sample matrix, however.

(2) Matrix-specific QC procedures. Matrix-specific QC procedures should be incorporated into the laboratory analysis to provide information on the precision and accuracy of the analyses on project samples. These procedures include analyses of field samples in association with surrogate compounds, matrix duplicates, matrix spikes, and matrix spike duplicates. On this same issue, matrix-specific procedures performed on other field samples at the laboratory not associated with the project samples are of no value other than from the batch perspective, for these samples do not provide information on the matrix under observation. It should also be noted that these additional analyses require the submittal of separate replicate samples to enable the lab's performance of the analysis. For this reason, the project requirements associated with matrix-specific QC procedures must be addressed very clearly within the SAP.

c. QA Objectives for chemical data measurement. Quality control procedures are operations employed during chemical analysis to support and document the attainment of established QA objectives. Batch and matrix-specific QC procedures were discussed above. All of the quality control procedures employed during the analysis, and subsequently reported, allow the calculation of precision and accuracy achieved both in general, and in conjunction with the project samples. The laboratory conducting the analytical work must be aware of, and be in agreement with, these project data quality objectives and be responsible for maintaining the project PARCC and sensitivity requirements. **If matrix problems or other unforeseen difficulties do not allow the criteria to be met, immediate notification to the appropriate USACE personnel (including technical personnel) is required.** Prior to release of data, the laboratory is responsible to review all data generated for compliance with the prescribed QA objectives. The contractor or USACE, upon receipt of the sample data package from the laboratory, will verify holding times were met and confirm the quality control procedures have been followed and the quantity and quality of data will adequately support the intended use of the data. This task should be performed according to the USACE guidelines for data validation. For contracted work, the original PARCC parameters and other project-specific objectives/requirements are used as the standard during the USACE final data review to ensure compliance with the contract. To avoid any misunderstandings concerning the level of quality required for the chemical analysis, the SAP must delineate very clearly all QA objectives through the applicable PARCC parameters and sensitivity requirements, including reporting requirements for the upcoming work effort. Comparability and representativeness are qualitative objectives of the data; while completeness goals, if defined for individual sampling and analytical protocols, are normally combined to assess, and are dictated by the expectations of the project as a whole. Precision and accuracy parameters, on the other hand, represent quantitative limits below which data are unacceptable. The

method of calculating these quantitative data quality indicators is presented in paragraph B-9.

(1) Precision. Precision examines the distribution of the reported values about their mean. The distribution of reported values refers to how different the individual reported values are from the average reported value. Precision may be affected by the natural variation of the matrix or contamination within that matrix, as well as by errors made in field and/or laboratory handling procedures. For example, procedural deviations in the way in which replicate samples are acquired or prepared, or incomplete homogenization prior to subsampling of replicates may affect precision. For chemical parameters which do not allow homogenization prior to sample acquisition (e.g., volatile organic analysis (VOA)), precision values must be viewed accordingly.

(2) Accuracy. Accuracy measures the bias in a measurement system and is difficult to measure for the entire data collection activity. Sources of error are the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analysis techniques. One aspect of sampling accuracy may be assessed by evaluating the results of field equipment (rinsate) and trip blanks. These data help to assess the potential concentration contribution from various outside sources. Analytical accuracy may be assessed through the use of known and unknown QC samples and spiked samples. Accuracy values can be presented in a variety of ways. The average error is one way; however, accuracy is more commonly presented as percent recovery or percent bias. Percent bias is the reciprocal of percent recovery. Accuracy is often determined from spiked samples. Every batch of samples analyzed shall include matrix spikes, laboratory control samples, and surrogate spikes, if appropriate.

(3) Representativeness. Representativeness expresses the degree to which sample data accurately and precisely represent the characteristics of a population of samples, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter which is most concerned with the proper design of the sampling program or subsampling of a given sample. The representativeness criterion is best satisfied by employing appropriate sampling strategies and techniques. In the laboratory, representativeness may be enhanced by making certain that all subsamples taken from a given sample are representative of the entire sample. The noting of sample characteristics in a case narrative will assist with the evaluation of prime contractor's data. Representativeness can be assessed by the use of duplicate field and laboratory samples. In this way, they provide both precision and representativeness information. Every batch of samples analyzed shall include matrix duplicates.

(4) Comparability. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved through using standard techniques to collect and analyze representative samples and reporting analytical results in appropriate units. Comparability is limited by the other PARCC parameters, because only when precision and accuracy are known can data sets be compared with confidence. In order that data sets may be comparable, it is imperative that contract required methods and procedures be explicitly followed. Any deviations shall be approved in advance.

(5) Completeness. Completeness is defined as the percentage of measurements made which are judged to be valid measurements compared to the total number of measurements planned. Specified levels of overall completeness, in addition to particular completeness goals for critical samples, should be set as part of the project DQOs. It is important that critical samples are identified and appropriate QA maintained to ensure that valid data are obtained in order to obtain the requisite type, quantity, and quality of data necessary to complete the project. The desired level of completeness is dependent on the project-specific data quality objectives. This information will be conveyed to the Contract Laboratory within the Scope of Work and/or project SAP.

(6) Sensitivity. Within different methods, sensitivity requirements are expressed differently. Because of these inconsistencies, care should be exercised when establishing the sensitivity requirements for a particular method and stating implicitly within the SAP what will be contractually required. Definitions of many of the limits expressed within EPA standard methods may be referenced within Appendix J. Firstly, the instrument detection limits (IDLs), method detection limits (MDLs), and practical quantitation limits (PQLs) published within USEPA methods are based upon a reagent water matrix, and ignore sample matrix interferences and the resulting effects on the limits. For this reason, statements are given within the methods that the published limits may not be achievable for environmental samples. These limits should, however, be achievable for the majority of quality control samples within a reagent water matrix (method blanks, LCSs, etc.) and compliance should be verified

during analytical results review or validation. The CRDLs and CRQLs published within CLP methodologies are contractually based levels and have nothing to do with what is instrumentally possible. Due to these facts, an attempt should be made to establish sensitivity requirements (PQLs for project samples) on a project-specific basis which addresses the following issues. Initially, the level must be based upon the data needs of the data user. These data needs may be associated with compliance issues as an MCL (maximum contaminant level), MCLG (MCL-goal), MCS (media cleanup standard), or other ARARs (applicable, or relevant and appropriate requirements). Other data users (e.g., risk assessor, design engineer) may require a toxicity reference concentration, a preliminary remediation goal, or other concentration of interest. **USACE recommends attempting to establish the project PQLs for field sample matrices at levels two to five times lower than the expressed project action levels, ARAR, or concentration of concern, depending upon the matrices involved, and the instrumentation capabilities.** Finally, this project-specific PQL level required must be compared to the levels proposed within the applicable methods to verify whether they are able to be attained instrumentally. Project PQLs ideally should be verified at levels that are at least two times greater than the method-specified MDLs, and should be between two and five times greater than the specified IDLs due to the potential differences between reagent water matrix used to generate the MDLs and IDLs and the project sample matrix. However, if the project PQLs are close to or lower than the limits proposed within the methods, it is unlikely they will be attainable for an environmental matrix without imposing method variations. Discussions with USACE laboratory personnel may be in order to identify options available to lower the limits proposed within the method. If this is unsuccessful, the data user is informed of this predicament, and a compromise must be reached. As noted earlier, the limits established within the methods may not be achieved for complex matrices, and flexibility should be maintained during this comparison. For long-term projects, or projects going to construction phase, the data user should suggest that the contract or USACE laboratory perform a detection limit study on project-specific samples at project start-up. The calculation that the laboratory is required to follow in assessing the method detection limit is presented in paragraph 9*d* of this appendix. **The final PQLs directed for each matrix of the project must be defined explicitly within the SAP.** It is the intent of this guidance that all target analytes reported be bracketed by appropriate standards. Therefore, target analytes detected below the lowest standard but above the project practical quantitation limit shall be reported as estimated values. **If very low levels of quantitation are required** (e.g., data used for a risk assessment or compliance issue), to avoid estimation of data based upon the above requirement, **it is suggested that the lowest calibration standard required in conjunction with the analysis be prepared at this PQL level.** Typically, the concentration of the lowest calibration standard is two to five times, and occasionally up to ten times the method MDL (PQL, etc.). Target analytes detected above the upper calibration standard shall also be reported as estimated values. In this case, however, the sample should be diluted and run again. This information must be conveyed within the project SAP.

B-5. Sample Handling, Custody, Preservation, and Holding Time Requirements

A table listing sample containers, preservation, and holding time requirements for soil/sediment and water is included in Appendix I. Requirements for the laboratory sample receipt documentation and sample custody are outlined within Appendix F. **Custody requirements of the laboratory may be elevated beyond those outlined based upon project objectives.**

B-6. Analytical Procedures

Individual instructions included in Appendix G present applicable testing methods for water, soil, and waste. The applicability of the individual methods to a project will be dependent upon the regulating authority the project is being performed under, as well as the level of data quality required to support the data needs and decisions of the project. Each instruction presents a complete analyte listing taken from the references noted within the instruction and their associated method detection limits. It should be noted that any project PQL requirements should be based upon project-specific DQOs as outlined in paragraph B-4*c*(6).

B-7. Calibration Procedures and Frequencies

a. Analytical support areas.

(1) Standard/reagent preparation. A critical element in the generation of quality data is the purity/quality and traceability of the standard solutions and reagents used in the analytical operations. Preparation and maintenance of standards and reagents will be performed per the specified methods. The contract laboratory shall continuously monitor the quality of reagents and standard solutions through a series of well-documented procedures. Primary reference standards and standard solutions used by the

contract laboratory shall be obtained from the National Institute of Standards and Technology, an EPA supplier, or other reliable commercial sources to ensure the highest purity possible. All standards and standard solutions are to be catalogued to identify the supplier, lot number, purity/concentration, receipt/preparation date, preparer's name, method of preparation, expiration date, and all other pertinent information. Both stock and working standard solutions shall be validated before use. Validation procedures can range from a check for chromatographic purity to verification of the concentration of the standard using a standard prepared at a different time or obtained from a different source. Stock and working standards shall be checked regularly for signs of deterioration, such as discoloration, formation of precipitates, or change in concentration. Care shall be exercised in the proper storage and handling of standard solutions, and all containers are labelled to identify the chemical(s), concentration, solvent, expiration date, initials of preparer, and date of preparation. Reagents are to be examined for purity by subjecting an aliquot or subsample to the analytical method in which it will be used. The contract laboratory shall not use standards or reagents in which the expiration dates are exceeded; and shall maintain complete documentation for all standards and reagents used.

(2) Balances. Analytical balances shall maintain an annual manufacture calibration and have a calibration check performed daily, or before each use, by laboratory personnel. This calibration check is conducted with two Class 'S' weights that bracket the expected balance use range. Balance calibrations shall be documented in appropriate hardbound log books with prenumbered pages.

(3) Refrigerators/freezers. All refrigerators and freezers shall be monitored for proper temperature by measuring and recording internal temperatures on a daily basis. Thermometers used for these measurements shall be calibrated annually at a minimum. Temperatures shall be recorded on appropriate log sheets. Appropriate acceptance ranges (2°-6° C for refrigerators) shall be clearly posted on each unit in service and corrective measures established if necessary.

(4) Water supply system. The contract laboratory shall maintain an appropriate water supply system that is capable of furnishing American Society for Testing and Materials (ASTM) Type II 'polished' water to the various analytical areas. The quality of the water shall be documented on a regular basis. An ion-exchange treatment is recommended for inorganic areas, and UV cartridges or carbon absorption treatments are recommended for organic purposes.

b. Laboratory instruments. Calibration of instruments is required to ensure that the analytical system is operating correctly and functioning at the proper sensitivity to meet established quantitation limits. Each instrument shall be calibrated with standard solutions appropriate to the type of instrument and linear range established within the analytical method(s). Assuring the validity of quantitative measurements at low concentrations is an extremely difficult technical problem. With regulatory action levels being continuously lowered, the validity of any given measurement becomes even more important. The consequences of false positive or false negative data can be significant. **Project PQLs are matrix-specific and should be established on a project-specific basis.** Tables of method proposed detection/quantitation limits are included within the individual analytical instructions in Appendix G for appropriate use in deciding an appropriate analytical method protocol and project PQL. **In addition to the requirements stated within the individual methods, USACE requires that all reported analytes are to be bracketed by an established calibration curve.** Due to the fact that standard methods allow the lowest standard to be up to ten times the concentration of the MDL, any positive values below this low-level standard and above the project PQL would be considered estimated. **To avoid qualifications of data based upon this requirement, the contract laboratory shall be required to analyze an additional low standard at or near the project PQL.** Frequency of calibration, calibration verification, and concentration of calibration standards are determined by the manufacturer's guidelines and the various analytical methods. **It is also the intent of USACE and this instruction that all batches of samples analyzed shall be bracketed by appropriate calibration verification standards.** If the calibration checks do not meet the established criteria, corrective action shall be taken. Corrective action is method-specific, and may include recalibration and reanalysis of samples. The necessary procedures include examination of instrument performance and analysis information, consultation with the supervisor, and a decision path to determine if recalibration and reanalysis of samples completed since the previous acceptable calibration check are warranted. All corrective action procedures implemented are to be documented, summarized within the case narrative, and submitted with the analytical results. **The USACE District needs to decide if a particular criterion is to be followed to decide if recalibration is necessary, and add language to this section.**

B-8. Internal QC Checks

The overall QA objective is to implement QC procedures during laboratory analysis and reporting that will provide data to the degree of quality consistent with their intended use. Refer to paragraph B-4*c* of this appendix for information on QA objectives for data measurement. The sample set, chemical analysis results, and interpretations must be based on data that meet or exceed the QA objectives established for the project. Internal QC checks are used to determine if analytical operations are in control, as well as determining the effect sample matrix may have on data being generated. These two aspects are described as batch QC and matrix-specific QC procedures, respectively. These procedures are described in paragraph B-4*b*. The type and frequency of specific QC samples performed by the contract laboratory shall be according to the specified analytical method and requirements outlined in the SAP. Each parameter's minimum laboratory QC, as outlined within the methods summarized, is located within the individual instructions within Appendix G. Acceptance criteria and/or target ranges for these QC samples are presented within the analytical methods, or may be altered based upon quantitative DQOs of the project. **It is suggested that these ranges or criteria, at a minimum, be equivalent to those specified within SW-846, or the contract laboratory program (CLP) Statements of Work.** It should be noted, however, that alternative methods to those mentioned above may not require internal QC sample analysis, or may not have established an acceptable range. Under those circumstances, project-specific criteria must be established within the SAP. Data which vary from these target ranges shall result in the implementation of appropriate corrective measures, potential application of qualifiers, and/or an assessment of the impact these corrective measures have on the usability of the data in the decision-making process. All corrective action requirements shall be addressed within the project SAP. At a minimum, full documentation of all actions taken must be recorded within a case narrative, and transmission of this information to USACE along with the data package is required. **In addition, USACE may require immediate verbal notification to the USACE Contracting Officer Representative (COR) or District chemist for input on corrective action requirements, deviations to protocol taken on future samples, final decisions of data usability, etc.** In order to clarify the internal QC requirements, the following subjects are defined to avoid misunderstandings.

a. Sample batch. Samples shall be extracted and analyzed in batches, not to exceed 20 samples, that are uniquely identified. The basic unit for analytical quality control is the batch. Two types of batches shall be identified, the preparation batch and the analytical, or instrumental, batch with each being uniquely identified. Samples that are prepared together shall be analyzed together. The only exception might be when specific samples being analyzed had failed QC parameters that required reanalysis in another analytical batch.

(1) Preparation batch. The preparation batch shall be defined as samples that are prepared together by the same person using the same equipment/glassware with the same method sequence and the same lots of reagents undergoing common manipulations for each sample within the same time period or in limited continuous sequential time periods. Samples in each preparation batch should be of similar matrix, e.g., water, soils, waste, etc. Each sample batch must contain all of the appropriate number and type of calibration standards, blanks, quality control samples, and analytical samples as defined by each analytical method and this instruction. The contract laboratory shall have sufficient quantities of extraction/digestion glassware/equipment to allow for the simultaneous preparation of a batch of samples. These requirements shall be summarized within the analytical methods.

(2) Analytical (instrumental) batch. The analytical, or instrumental batch shall be defined by USACE as samples that are analyzed together within the same analytical run sequence, within the same time period or in continuous time periods. In general, if an instrument is not used for periods of time or shut down (e.g., overnight, etc.), then a new batch must be started. Analytical batches can, however, be analyzed back to back, within continuous time periods, without interruption. **This restriction may be relaxed, if permitted by the analytical method, to allow an instrument left operative, but in a stand-by mode for a limited amount of time (e.g., overnight). The laboratory may then begin an instrumental batch if all laboratory QC samples confirm that instrumental performance is within established control limits.** Each analytical sample batch must contain all of the appropriate number and type of calibration solutions, QC samples, and analytical samples as defined by each analytical method. Field QC samples are addressed based upon project-specific requirements and not discussed further.

b. Batch QC.

(1) Method blanks. Method blanks are analyzed to assess the level of background interference or contamination that exists in the analytical system and that might lead to the reporting of elevated concentration levels or

false positive data. The method blank is defined as a blank matrix to which all reagents are added in the same volumes or proportions as used in sample preparation and carried through the complete sample preparation and analytical procedure. At least one method blank will be analyzed with every batch of samples processed. Results of the method blank analysis are evaluated, in conjunction with other QC information, to determine the acceptability of the data generated for that batch of samples. Criteria for determining blank acceptability must be based on consideration of the analytical techniques used, analytes reported, and quantitation limits required. The following criteria are taken from SW-846, and shall be used to evaluate the acceptability of blank data: the concentration of all target analytes shall be below the method detection limit, or 5 percent of the regulatory limit for that analyte, or 5 percent of the measured concentration in the sample. If the blank does not meet acceptance criteria, the source of contamination shall be investigated and appropriate corrective action shall be taken and documented. Investigation includes an evaluation of the data to determine the extent and effect of the contamination on the sample results. Corrective actions may include reanalysis of the blank and/or repreparation and reanalysis of the blank and all associated samples at no expense to the government. Sample results shall not be corrected for blank contamination.

(2) Laboratory control samples. Laboratory performance QC shall be based on the use of standard control matrices that are prepared independently from the standard solutions used in establishing the calibration curve, to calculate precision and accuracy data. These QC data are compared daily or on a per-batch basis, to established control limits, which must be as stringent as those stated within the individual methods to verify compliance. This data, along with method blank data, shall be used to assess daily laboratory performance.

(3) Other QC samples. Additional appropriate QC requirements are detailed within the analytical methods and are briefly outlined in the individual instructions in Appendix G.

c. Matrix-specific QC. Matrix-specific QC shall be based on the use of an actual environmental sample for precision and accuracy determinations and commonly relies on the analysis of matrix duplicates, surrogate compounds, matrix spikes, and matrix spike duplicates. The required frequency of these sample types is established within the analytical method, or as specified for the project. Results of these samples, supplemented with field blank results, shall be used to assess the effect of sample matrix and field conditions on analytical data.

B-9. Calculation of Data Quality Indicators

a. Precision. Precision can be measured in a variety of ways. For chemical analysis of environmental samples, precision is commonly determined from duplicate sample analyses; thus, precision is usually expressed as relative percent difference (RPD). Every batch of samples analyzed shall include matrix duplicates and/or matrix spike duplicates to evaluate precision in this manner. Precision determined by RPD shall be calculated as follows.

$$RPD = \left(\frac{|X_1 - X_2|}{((X_1 + X_2) / 2)} \right) \times 100\%$$

If sufficient replicates are taken from a particular matrix for a project (minimum of eight), precision may be estimated as the Relative Standard Deviation (RSD), or Coefficient of Variation. This value assesses the precision of the sample population within that matrix. Precision determined as RSD shall be calculated as follows, where σ is the population standard deviation.

$$RSD = CV = \left(\frac{\sigma}{\bar{x}} \right) \times 100\%$$

$$\sigma = [\Sigma (x_i - \bar{x})^2 / (n - 1)]^{1/2}$$

b. Accuracy. Analytical accuracy may be assessed through the use of known and unknown QC samples and spiked samples. Accuracy values can be presented in a variety of ways. Average error is one way; however, accuracy is more commonly presented as percent recovery or percent bias. Percent bias is the reciprocal of percent recovery. Accuracy is often determined from spiked samples. Accuracy determined by percent recovery is calculated as follows:

$$\%R = \left(\frac{(X_S - X_U)}{K} \right) \times 100\%$$

where

X_s = measured value of the spiked sample

X_u = measured value of the unspiked sample

K = known amount of the spike in the sample

c. Completeness. Completeness may be calculated for the project as a whole as follows:

$$\%C = \left(\frac{V}{N}\right) \times 100\%$$

where

V = number of measurements judged valid

N = number of valid measurements needed to achieve a specified statistical level of confidence

d. Method detection limit (MDL). MDL studies shall follow the procedures outlined in 40 CFR 136, Appendix B. The method detection limit is normally calculated using data generated from reagent grade water. However, this would also apply if required to assess the detection limit associated with a specific project matrix. MDL is defined as follows:

$$MDL = t_{(n-1,\ 1-\alpha\ =\ 0.99)}\ (S)$$

where

$t_{(n-1,\ 1-\alpha = 0.99)}$ = Students' t-value appropriate to a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom

S = standard deviation of the replicate analyses

B-10. Corrective Actions

When errors, deficiencies, or out-of-control situations exist, the contract laboratory's QA plan shall provide systematic procedures, called corrective actions, which shall be implemented to resolve problems and restore proper functioning to the analytical system. Contract laboratory personnel are alerted that corrective actions are necessary if the following conditions exist: (1) Any QC data are outside the acceptable windows for precision and accuracy; (2) Blanks, laboratory control samples containing contaminants above acceptable levels, occur. USACE policy for acceptable laboratory blank contamination is in accordance with SW-846, third edition, Update 1, Chapter 1. This states "For a blank to be acceptable for use with the accompanying samples, the concentration in the blank of any analyte of concern must be no higher than the method detection limit (MDL);" (3) Undesirable trends are detected in spike or surrogate recoveries or RPD between duplicates; (4) There are unusual changes in method detection limits; (5) Deficiencies are detected by the QA department during internal or external audits or from the results of performance evaluation samples; (6) Inquiries concerning data quality are received from USACE. Corrective action procedures are often handled at the bench level by the analyst, who reviews the preparation procedure for possible errors, checks the instrument calibration, spike, surrogate, calibration solutions, instrument sensitivity, and so on. If the problem persists or cannot be identified, the matter is referred to the laboratory supervisor, manager, and/or QA department for further investigation. Once resolved, full documentation of the corrective action procedure shall be filed with the project records, and the information summarized within the case narrative. The following corrective actions and/or procedures will be required as follows:

a. Incoming samples. Problems noted during sample receipt shall be documented on an appropriate form (Cooler Receipt Form). USACE shall be contacted immediately for problem resolution. All corrective actions taken shall be thoroughly documented.

b. Sample holding times. If samples cannot or were not extracted/digested and/or analyzed within the appropriate method required holding times, USACE shall be notified immediately for problem resolution. All corrective actions shall be thoroughly documented.

c. Instrument calibration. Sample analysis shall not be allowed until all initial calibrations meet the appropriate requirements. All calibrations must meet method time requirements or recalibration must be performed. All continuing calibrations that do not meet method requirements shall result in a review of the calibration, rerun of the appropriate calibration standard(s), and if necessary, reanalysis of all samples affected back to the previous acceptable calibration check.

d. Practical quantitation limits. Appropriate sample cleanup procedures shall be employed to attempt to achieve the practical quantitation limits as stated in the

following instructions. **If difficulties arise in achieving these limits due to a particular sample matrix, the contract laboratory should notify the USACE COR and District chemist of this problem for resolution.** Any dilutions made shall be documented in a case narrative along with the revised practical quantitation limits for those analytes directly affected. Analytes detected above the method detection limits, but below the practical quantitation limits shall be reported as estimated values.

e. Method QC. All method QC, including blanks, matrix duplicates, matrix spikes, matrix spike duplicates, surrogate recoveries, laboratory control samples, and other method-specified QC samples shall meet the requirements as specified within the analytical method, as specified in this appendix, and within the project SAP. Failure of method-required QC shall result in the review of all affected data. If no errors can be noted, the affected sample(s) shall be reanalyzed and/or re-extracted/redigested, then reanalyzed within method-required holding times to verify the presence or absence of matrix effects. In order to confirm matrix effects, QC results must observe the same direction and magnitude (**ten times**) bias. If matrix effect is confirmed, the corresponding data shall be flagged accordingly using USACE flagging symbols and criteria as defined by the USACE Functional Guidelines for Data Validation. If matrix effect is not confirmed, then the entire batch of samples may have to be reanalyzed and/or re-extracted/redigested, then reanalyzed at no cost to the government. USACE shall be notified as soon as possible to discuss possible corrective actions should unusually difficult sample matrices be encountered.

f. Calculation errors. Reports shall be reissued if calculation and/or reporting errors are noted with any given data package. The case narrative shall clearly state the reason(s) for reissuance of a report.

B-11. Data Reduction, Review/Validation, and Reporting

All analytical data generated by the contract laboratory shall be extensively reviewed prior to report generation to assure the validity of the reported data. This internal data review process shall consist of data generation, reduction, a minimum of three levels of documented review, and reporting. In each stage, the review process shall be documented using an appropriate checklist form that is signed and dated by the reviewer.

a. Data reduction. Reduction procedures must be summarized and the persons responsible for this task identified within the SAP. These procedures should address any statistical approaches used for reducing data, and include applicable units and any term definitions.

b. Data review. The analyst who generates the analytical data has the prime responsibility for the correctness and completeness of that data. Each step of this review process involves evaluation of data quality based on both the results of the QC data and the professional judgement of those conducting the review. This application of technical knowledge and experience to the evaluation of data is essential in ensuring that data of quality are generated consistently. All data generated and reduced shall follow well-documented in-house protocols.

(1) Level 1 technical data review. Analysts review the quality of their work based on an established set of guidelines. Review criteria as established in each method, in this instruction, and as stated within the contract laboratory Quality Management Manual shall be used. The review shall at a minimum ensure that: (1) sample preparation information is correct and complete; (2) analysis information is correct and complete; (3) appropriate SOPs have been followed; (4) analytical results are correct and complete; (5) QC samples are within established control limits; (6) blanks and laboratory control samples are within appropriate QC limits; (7) special sample preparation and analytical requirements have been met; and (8) documentation is complete (any anomalies have been documented and forms completed, holding times documented, etc.). Level 1 data review shall be documented by using a checklist form with a signature and date entered by the reviewer.

(2) Level 2 technical review. Level 2 review shall be performed by a supervisor or data review specialist whose function is to provide an independent review of the data package. This review shall also be conducted according to an established set of guidelines and is structured to ensure that: (1) all appropriate laboratory SOPs have been followed; (2) calibration data are scientifically sound, appropriate to the method, and completely documented; (3) QC samples are within established guidelines; (4) qualitative identification of sample components is correct; (5) quantitative results are correct; (6) documentation is complete and accurate (any anomalies have been documented and forms completed, holding times documented, etc.); (7) data are ready for incorporation into the final report; and (8) the data package is complete and ready for data archive. Level 2 review shall be structured so that all calibration data and QC sample results are reviewed and all of the analytical results from at least 10 percent of the samples are checked back to the sample

preparation and analytical bench sheets. If no problems are found with the data package, the review is complete. If any problems are found with the data package, an additional 10 percent of the sample results shall be checked back to the sample preparatory and analytical bench sheets. This cycle then repeats until either no errors are found in the data set checked or all data have been checked. All errors and corrections noted shall be documented. Level 2 data review shall also be documented on a checklist with the signature and date of the reviewer.

(3) Level 3 administrative data review. Level 3 review is performed by the quality assurance officer or the program administrator at the contractor laboratory. This review should be similar to the review as provided in Level 2 except that it should provide a total overview of the data package to ensure its consistency and compliance with this instruction. All errors noted shall be corrected and documented. Level 3 data review shall also be documented on a dated checklist with the signature of the reviewer.

c. Data validation. An independent validation of the data may be required based upon regulatory or customer request. These procedures must be performed by personnel independent of the laboratory generating the data. All procedures should follow appropriate Functional Guidelines for Data Validation (USACE, USEPA federal, or USEPA regional) based upon project objectives to accomplish this task.

d. Data reporting. Two data reporting formats may be anticipated for use with USACE projects: (1) a data package that is forecast to be submitted to the USACE Quality Assurance Laboratory for CQAR generation, and (2) a data package that can be fully validated (e.g., similar to CLP). These standard reporting formats require (1) the reporting of all data along with the supporting QC information; and (2) another reporting format (the full package as defined by the USACE Functional Guidelines for Data Validation (or USEPA if applicable)). Either data package shall include a table that matches up primary and QA samples. An example of such a table can be found on page H-2. These reporting formats may change due to changes in the various regulatory agency policies and requirements and the laws which any particular method falls under. Upon request, an electronic deliverable may also be required with each format which will allow the automated uploading of analytical data to the associated USACE QA laboratory. In addition, the schedule of data deliverable submission should be established (e.g., 30 to 60 days post receipt of last sample). For comprehensive projects that involve a substantial number of samples, or projects that require continued monitoring, the use of interim data deliverables for reporting is recommended. These deliverables should be submitted after a proposed milestone instead of at project completion.

(1) Standard data reporting format. Contract laboratory reports shall be structured to clearly present all of the contract required items. This report shall be organized as follows:

(a) General discussion. The general discussion shall include a description of the sample types received, tests performed, problems encountered, and general comments shall be given here. This section shall include any case narratives. The project shall be clearly identifiable. A table shall be presented that clearly shows all samples received, and includes the contract laboratory sample identification number, the sample matrix, and the tests assigned. Another table shall be presented that summarizes all failed QC parameters along with corrective actions taken by the contract laboratory.

(b) Analytical data. Data shall be reported by sample or by test. Pertinent information shall include, at a minimum, field sample identification number, contract laboratory sample number, date of sample collection, date sample was received at the contract laboratory, date(s) sample was extracted/digested/analyzed, batch number(s), dilution factors, all analytes tested for and their associated reporting limits, any data qualifiers assigned, matrix, units, percent of solids for solid samples, and sample description, including preservation. Any other factors that could affect the sample results shall also be noted. Data for solid samples shall be reported on a dry weight basis. Both the original and diluted results shall be reported for samples that are reanalyzed due to certain analytes that have exceeded the calibration ranges. Results may be combined on a single report. Data qualifiers used should be referenced from the guidance document utilized for data validation (USACE or USEPA).

(c) Calibration information. All initial calibration curve data must be presented. All continuing calibration verification data to include standards and blanks must be presented with acceptance ranges clearly shown.

(d) Laboratory performance and matrix-specific information. All of the associated method QC information, even if this information was run on samples other than those associated with this project, shall be reported. This information shall include method blanks, laboratory control samples, matrix duplicates, matrix spikes, matrix spike duplicates, and other method-specific QC samples

that may have been run. Spiking levels shall be clearly shown. This QC information must be specific to the batch that the field sample analysis was associated with. Batch numbers shall be clearly shown. Method-specific QC information must be reported with all acceptance criteria clearly shown. All method QC must meet the acceptance requirements as stated within the method within the project SAP, or in this instruction. Any deviations from this acceptance criteria must be identified with appropriate corrective actions that have been conducted, and documented.

(e) Other information. Any other information that is pertinent to the project samples shall be reported. This shall include copies of the original chain of custody forms, copies of cooler receipt forms, copies of any telephone conversation records, and copies of any other forms (e.g., corrective action forms, level 1, 2, and 3 review checklists, validation forms, etc.). The laboratory shall maintain on file all of the supporting data and documentation for these samples. The contract laboratory shall provide, upon request, copies of raw data as USACE deems necessary for specific methods and samples, at no additional cost.

(2) Fully validatable data reporting package format. This reporting format is specified by the USACE Functional Guidelines for Data Validation, in order to allow a full independent validation of the data. If the project requires involvement in the CLP program or following CLP format, format and guidance should comply with USEPA requirements. The equivalent electronic deliverable shall also be included with the hard copy report.

(3) Electronic data reporting. The USACE District chemist shall be contacted for information on this subject as it applies to delivery of data to the government QA laboratory. In addition, depending upon the data users involved with a project (Installation Restoration Program (IRP), AEC), information over their electronic format requirements (IRPMIS, IRDMIS (Department of Defense environmental databases)) may be placed here.

e. Laboratory turnaround time. Turnaround time shall be 21 calendar days for standard delivery from the time of sample receipt, unless accelerated turnaround times are requested and agreed upon.

B-12. Preventative Maintenance

To minimize downtime and interruption of analytical work, preventative maintenance shall be routinely performed on each analytical instrument. Designated laboratory personnel should be trained in routine maintenance procedures for all major instrumentation. When repairs are necessary, they shall be performed by either trained staff or trained service engineers employed by the instrument manufacturer. Maintenance contracts should be maintained on all major analytical instruments. All maintenance or repairs conducted shall be detailed within logbooks, unique to each instrument. Backup instrumentation shall be designated in case of an extended breakdown for a piece of analytical instrumentation. It is the responsibility of the contract laboratory to have a backup plan in force such that all sample holding times can be met. This plan can include the use of another USACE validated laboratory. Before subcontracting is initiated, USACE personnel must be informed and approval given, in writing, from the USACE COR and the USACE HTRW Mandatory Center of Expertise (MCX).

B-13. Performance and System Audits

Performance and system audits will be performed onsite as specified within the SAP, and performed at the laboratory at a frequency decided during the laboratory validation process as specified within ER 1110-1-263. This frequency may, at the option of the USACE COR, be increased. A corrective actions report shall be required that addresses any deficiencies noted during audits conducted during the project and included within the project file.

Appendix C
Environmental Sampling Instructions

C-1. Sampling Strategies

a. Scope of application. This section discusses various sampling strategies that can be employed when sampling various media, including but not limited to soils, sediments, or water. Several different types of sampling strategies exist that can be categorized as either a statistical or non-statistical method. Applications and limitations of each sampling strategy will be briefly described.

b. Sampling strategies. One of the main goals of any investigation is to collect samples that are representative of the site conditions so that an accurate assessment of contamination can be made with a minimum number of samples. To ensure that samples are as representative as possible, statistics are often used to select the appropriate sampling strategy. Typically, more than one approach is used and most sampling plans employ a combination of sampling strategies. Table C-1, "Comparison of Sampling Strategies," summarizes basic descriptions, applications, and limitations for frequently used sampling strategies. The various sampling strategies available can be grouped into two basic categories: classical statistical and non-statistical methods. Because of the spatial variability limitations of soil, discussions on sampling strategies using classical statistical techniques are frequently used with the sampling of solid media. However, classical statistical methods are also applicable to sampling of other media, including groundwater and surface water. For a more detailed presentation of the implementation of each of these sampling strategies, refer to other USACE guidance on the planning of hazardous, toxic, and radioactive waste sites.

(1) Classical statistical sampling. A discussion of statistical sampling is presented below. For a detailed discussion of classical statistical methods see Environmental Protection Agency (EPA) 1530-SW-89-026.

(a) Simple random sampling. Simple random sampling is the most basic statistical approach and is usually applied when minimal site background information (e.g., past practices, uses of hazardous materials, etc.) is available and visible signs of contamination are not evident during the initial site survey. This strategy uses the theory of random chance probabilities to choose representative sampling locations. Each sample location is chosen independently of any previously chosen sample location. It is most effective when the number of available sampling points is large enough to lend statistical validity to the random selection process. The simple random sampling approach may be more costly than other statistical methods since a larger number of samples may be required to characterize the site.

(b) Stratified random sampling. Investigations of large sites that encompass a number of soil types, topographic features, or land uses may benefit by using a modified random sampling approach, called "stratified random sampling." In this strategy, the site is divided into different sampling areas (strata) that are internally homogeneous based on existing data and background information. The division of the site into strata is based on the assumption that each stratum is more internally homogeneous than the site as a whole. Each stratum is sampled at locations based on a simple random sampling approach. By grouping similar sampling points together and treating each group separately, each with its own individual random sampling scheme, the precision of the study is increased. In addition, this approach controls the variability due to contaminant concentration, location, terrain type, etc., and it often results in more efficient allocation of resources than would be possible with a simple random sampling method. Sampling analyses from each stratum may be used to determine the mean or total contaminant concentration within the stratum. However, data from each stratum may be used to make comparisons between the different strata or combined to provide information about the entire site.

(c) Systematic grid. Systematic grid sampling, sometimes referred to as systematic random sampling, is the most common statistical sampling strategy. It involves collecting samples at predetermined, regular intervals (i.e., within a grid pattern). The location of the first sampling point is selected at random and all subsequent sample locations are determined using a systematic pattern from that point. This approach is typically used when a large site (e.g., measured in acres) must be sampled to characterize the presence and distribution of contaminants. The grid-based option is probably the best classical statistical sampling strategy for minimizing bias and providing complete site coverage. The most basic grid system is a straight line between two points on which regularly spaced sampling locations are designated. This one-dimensional sampling grid may be used for sampling along a straight drainage ditch or other man-made feature. However, most soil sampling schemes require a two-dimensional grid system for locating sampling points.

Table C-1
Comparison of Sampling Strategies

Sampling strategy	Description	Application	Limitations
Classical statistical sampling strategies:			
Simple random sampling	Representative sampling locations are chosen using the theory of random chance probabilities	Sites where background information is not available and no visible signs of contamination are present.	May not be cost-effective because samples may be located too close together. Does not take into account spatial variability of media.
Stratified random sampling	Site is divided into several sampling areas (strata) based on background or site survey information; each stratum is evaluated using a separate random sampling strategy	Large sites characterized by a number of soil types, topographic features, past/present uses, or manufacturing/storage areas.	Often more cost-effective than random sampling. More difficult to implement in the field and analyze results. Does not take into account spatial variability of media.
Systematic grid sampling	Most common statistical strategy; involves collecting samples at predetermined, regular intervals within a grid pattern	Best strategy for minimizing bias and providing complete site coverage. Can be used effectively at sites where no background information exists. Ensures that samples will not be taken too close together.	Does not take into account spatial variability of media.
Hot-spot sampling	Systematic grid sampling strategy tailored to search for hot spots	Sites where background information or site survey data indicate that hot spots may exist.	Does not take into account spatial variability of media. Tradeoffs between number of samples, chance of missing a hot spot, and hot spot size/shape must be weighed carefully.
Geostatistical approach	Representative sampling locations are chosen based on spatial variability of media. Resulting data are analyzed using kriging, which creates contour maps of the contaminant concentrations and the precision of concentration estimates.	More appropriate than other statistical sampling strategies because it takes into account spatial variability of media. Especially applicable to sites where presence of contamination is unknown.	Previous investigation data must be available and such data must be shown to have a spatial relationship.
Non-statistical sampling strategies:			
Biased sampling	Sampling locations are chosen based on available information.	Sites with specific known contamination sources.	Contaminated areas can be overlooked if they are not indicated by background information or visual signs of contamination. Best used if combined with a statistical approach, depending on the project objectives.
Judgmental sampling	An individual subjectively selects sampling locations that appear to be representative of average conditions.	Homogeneous, well-defined sites.	Not usually recommended due to bias imposed by individual, especially for final investigations.

Two types of grids are generally used: square grids and triangular grids. Sampling is usually performed at each grid-line intersection (i.e., each place where the grid lines cross). However, sampling in the center of each grid square/triangle or obtaining a composite of samples within a grid square/triangle is also acceptable.

(d) Hot-spot sampling. "Hot spots" are usually defined as small, localized areas of a media that are characterized by high contaminant concentrations. In order to detect hot spots, a special systematic grid sampling approach is necessary. However, because all of the media cannot be sampled, there is still a possibility that hot spots exist even if none are discovered during the sampling process. Statistical approaches for detection of hot spots are discussed in Gilbert (1987). A hot-spot sampling plan should consider the following factors:

(1) Grid spacing and geometry. A triangular grid pattern increases the efficiency of the hot spot search. In

addition, the probability of finding hot spots increases as the spacing between grid points decreases.

(2) Hot-spot shape/size. The larger a hot spot is, the more likely it is to be discovered. The shape of the hot spot also affects the probability of it being detected. Narrow or small-circular patterns may escape detection because they are located between grid sampling locations. Large-circular and wide-elliptical hot spots are the easiest to find.

(3) False negative rate. This measures the probability that a hot spot will be missed even if one is present.

(e) Geostatistical approach. Classical statistical methods for the design of sampling projects are well-known and have been the standard approach in the past. However, these strategies have one major drawback--they do not take the natural variability of the media into account. As such, they may not adequately characterize contamination at sites, especially those sites that are fairly heterogeneous and/or where the presence of contamination is unknown. Consequently, classical statistical methods are most appropriately applied to sites where the source of contamination is known (e.g., a landfill, waste pile, etc.) or small sites where the entire area is to be remediated as a unit (e.g., in the case of soils, the entire site will be solidified). To more accurately characterize sites where the presence of contamination is unknown, statisticians now believe that geostatistical methods are more appropriate than classical statistical methods because they take into account the spatial variability of the media when estimating contaminant concentrations. Geostatistical methods may be used for sampling naturally occurring materials such as soils or groundwater and man-made units such as landfills or waste piles. Characterization of any media is difficult because contaminant levels are spatially correlated. This means that contaminant concentrations from samples taken close together are more likely to be similar than contaminant concentrations from samples taken farther apart (regional variability). Geostatistics describes how to sample and analyze regional variability by defining the representativeness of a sample in terms of its range of correlation or zone of influence. For example, a sample location selected through geostatistics will represent a circular area with a radius less than or equal to the zone of influence. In other words, the sample would be representative of the media within the circular area. A two-stage sampling approach is typically used in geostatistical sampling strategies. Initially, a sampling survey is performed to collect basic data. These data are used to create a graph that defines the distance over which samples are representative. This graph is then used to dictate the shape, size, and orientation of another systematic grid that is used in the second, final sampling event. Geostatistical sampling strategies are relatively complex, and further discussions of this approach are found in Borgman and Quimby (1988), Gilbert (1987), and "The Hazardous Waste Consultant" (1992).

(2) Non-statistical sampling. A discussion of non-statistical sampling is presented below.

(a) Biased sampling. Biased sampling is used to evaluate sites with specific, known sources of contamination (e.g., the site-survey-discovered visible signs of contamination or records indicate that certain locations are suspect based on past/present practices). As such, sampling locations are chosen based solely on available information.

(b) Judgmental sampling. In judgmental sampling schemes, an individual subjectively selects the sampling locations that appear to be representative of average conditions. If the individual is knowledgeable, judgmental sampling can result in accurate estimates of site conditions. Although a certain amount of judgment is necessary in any sampling approach, total reliance on judgment decisions is not recommended because an individual's bias often leads to poor quality data and improper conclusions. However, if judgmental sampling is necessary, multiple samples should be collected to add some measure of precision.

c. Potential problems. Table C-1 shows the limitations associated with the above sampling strategies.

C-2. Groundwater Sampling

a. Scope of application. Instructions presented in this section are for collecting representative groundwater samples from temporary and permanent groundwater monitoring wells and, where applicable, other push-in well screen samplers. Typical groundwater monitoring wells are 2 or 4 in. in diameter and are constructed of PVC or stainless steel. Instructions presented here are intended to include sample collection from wells that have not been completed as production or extraction wells. The instructions can be used to identify an appropriate sampling protocol for the acquisition of a representative sample. Instruction C-4, "Potable Water Sampling," includes procedures for sampling permanent production wells or any other well constructed with a discharge tap. Instructions for purging and sampling wells by the following techniques are included in this section: bailer,

portable submersible pump, bladder pump, hand pump, centrifugal pump, peristaltic pump, and air lift pump.

b. Sampling strategies. Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed for a particular site will influence several project decisions, including, but not limited to, sampling locations, types of samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels, and the problems associated with trace level cross contamination. A more detailed discussion of the issues to consider when developing sampling strategies is presented in other USACE guidance documents. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme for purposes of characterizing a hazardous waste site should follow the fundamentals of the scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to ambient conditions, vertical extent, horizontal extent, and mobility in various media.

(1) Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to identify contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. When evaluating a site, sampling can be conducted by random, systematic, or biased sampling. Instruction C-1 discusses random, systematic, and biased sampling in detail. Often biased and random sampling techniques can be used together to thoroughly address an entire site. Some wells may be biased to potentially contaminated areas (e.g., former wastewater lagoons, former process or disposal areas) or potentially impacted areas (e.g., down-gradient locations). In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Groundwater monitoring wells are positioned at locations and depths to satisfy groundwater monitoring objectives. Groundwater samples collected from monitoring wells are evaluated as discrete samples collected from the same location. Groundwater samples collected from the same well are distinguished from each other because they are distributed through time. Unless each groundwater monitoring well has a sampler dedicated to the well, the order of sampling monitoring wells should be from the least contaminated wells to the most contaminated wells.

(2) Sample type. Groundwater samples are typically discrete samples. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected at once and at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, since contamination in groundwater disperses over time and distance, it will take more grab samples to characterize the extent of contamination as the time from a release increases.

(3) Suggested samplers. Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, well diameter, depth to groundwater, limitations of lift capacity of the sampling device, specified analytical parameters, and ease of decontamination vary from technique to technique. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) Sample frequency. Contaminant concentrations in groundwater vary across both time and space. Therefore, it is important to consider the potential temporal variability of the data collected. Determination of the number of samples needed to characterize a site is dependent upon the objectives and the site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is known to be contaminated and the objective is to establish the boundaries of the groundwater contamination or trends in the data over time, a greater number of samples may be needed. In many cases statistical considerations can be helpful in determining sampling strategy.

c. Sample preservation and handling. Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in groundwater monitoring programs are not chemically stable, and therefore sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical*

Methods (SW-846). Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2 of Appendix F, "Packaging and Shipping Procedures." Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. Samples should be transferred in the field from the sampling equipment directly into the container that is required for that analysis or set of compatible parameters. The sample should then be preserved in the field as specified in Appendix I. Because of the low analytical detection limits that are required for certain data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. The samples for volatile analysis should be carefully transferred directly from the sample collection device to the sample container in order to minimize contaminant loss through agitation/volatilization or adherences to another container. Samples should be collected in the order of the parameter shown in Section C-2c(1). If more than one container is required per parameter, the sample should be split equally among all containers until filled. Containers used to collect samples for organic analyses should not be pre-rinsed with water because of the possibility that additional contaminants could adhere to the sample container and taint the analytical results.

(1) Sample containers. When metals are the analytes of interest, high density polyethylene containers with polytetraflouroethylene-lined polypropylene caps should be used. (Polytetraflouroethylene is commonly referred to using the registered name of Teflon. Polytetraflouroethylene will be referred to as PTFE.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Appendix G, Analytical Techniques/Procedures, contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of precleaned bottles should be verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Refer to Appendix I or the specific analytical method in Appendix G for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common groundwater parameters follows.

(a) Volatile organics (VOA).

(b) Purgeable organic carbon (POC).

(c) Purgeable organic halogens (POX).

(d) Total organic halogens (TOX).

(e) Total organic carbon (TOC).

(f) Extractable organics.

(g) Total metals.

(h) Dissolved metals.

(i) Phenols.

(j) Cyanide.

(k) Sulfate and chloride.

(l) Turbidity.

(m) Nitrate and ammonia.

(n) Radionuclides.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, retard hydrolysis, and reduce sorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light. Pre-preserved sample containers should not be used. Because different amounts of preservative may be necessary to bring the sample to the required pH, USACE policy is to add the preservative to the container in the field. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) Special handling for VOA samples. Water samples to be analyzed for purgeable organic compounds should be stored in 40-ml septum vials with screw caps and like all other samples, a PTFE-silicone disk should be placed in the cap to prevent contamination of the sample by the cap. Disks should be placed in the caps (PTFE side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program. The 40-mL vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence that could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a

"convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After the bottle is capped, it should be turned over and tapped to check for bubbles. If any bubbles are present, the procedure must be repeated. Care should be taken to ensure that no loss of preservative occurs, if applicable.

(4) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) All work should be conducted on a clean surface, such as a stainless steel table.

(c) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(d) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(e) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(f) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(g) Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

(h) Collection of adequate field control samples.

d. Sampling methods. Sampling instructions for the most common techniques for collecting groundwater samples from groundwater monitoring wells are presented in this section. A summary of the methods is presented in Table C-2. Additional information is presented in EPA/ 625/R-93/003. After completion of the well installation, the well should be developed to remove any fine material adjacent to the well casing. Because the well should be developed more than 48 hr prior to purging and sampling the well, well development is not addressed in this sampling and analysis guidance document. Refer to other USACE guidance for further information on well development. Once a well has been located and properly identified, field measurements should be noted in a bound field logbook. A cross reference should be made between the previously recorded physical location/identification locating the well to be sampled, to ensure the proper well has been selected. Misidentification of a sampling point in the field will result in erroneous data that may affect management decisions. Also included in field measurements are the physical measurements of the well, and its physiochemical parameters. Physical measurements that may also be recorded in the field logbook include the presence and diameter of protective casing, diameter and construction material of the well casing, total depth of well from the top of casing, surveyor's mark, depth from top of casing to water, and the volume of water in the well and filter pack. The volume of water can be calculated by calculating the submerged length of the well and calculating the volume of water in the submerged casing and filter pack. Volumes of water in various well casing diameters are as follows:

Water Volume in Casing

Nominal Casing Diameter Inches (centimeters)	Gallons/Linear Ft. (Liters/Linear Meter)
2 (5.1)	0.16 (2.03)
4 (10.2)	0.65 (8.11)
6 (15.2)	1.47 (18.24)
8 (20.3)	2.61 (32.43)
10 (25.4)	4.08 (50.67)
12 (30.5)	5.88 (72.96)

Table C-2
Summary of Groundwater Sampling Techniques

	Compatible Construction Material	Ease of Use	Economical	External Power Source Needed	VOC Degassing	Ease of Decontamination	Large Water Volumes	Restrictive Groundwater Depth
Bailer	•	•	•			•		
Submersible Pump	•			•	•		•	
Bladder Pump	•			•				
Hand Pump	•	•	•		•			
Centrifugal Pump			•	•	•		•	•
Peristaltic Pump	•			•	•	•		•
Air-Lift Pump		•		•	•		•	•

The volume of water in the filter pack should be calculated assuming a porosity of 30 percent within the filter pack. The volume of water present in the well casing and filter pack may be calculated as shown in the example below.

Example:

Assumptions: 2-in. well casing; well depth is 100 ft below ground surface, groundwater depth is 20 ft below the ground surface, and the boring diameter is 8 in.

Volume of water in well = (well depth-depth to water) x (water volume in casing)
= (100-20) ft (0.1632 gal/ft)
= 13.0 gal

Volume of water in filter pack = (volume of filter pack) x 30%/231 $in.^3$/gal
= ([π (8 in.)^2/2) x 80 ft (12 in./ft)) x 0.3/231 $in.^3$/gal
= 58.7 gal

Total volume in well casing and filter pack = 13 gal + 58.7 gal
= 71.7 gal

The volume of water in any size casing can be determined using the following formula.

$$\text{No. of gallons} = 5.8752 \times C^2 \times H$$

Where C = Casing diameter, feet

H = Height of water column, feet

In addition to the physical measurements taken above and other information that may identify the well, physiochemical information such as specific conductance, pH, temperature, turbidity, and dissolved oxygen should be recorded initially (and in that order), during purging and prior to sampling (see following section).

(1) Well purging. To obtain a representative sample of groundwater from a groundwater monitoring well, the water that has stagnated and/or thermally stratified in the well casing must be purged or evacuated. The purging procedure allows fresh or representative groundwater to enter the well. The optimum or preferred method to ensure that fresh water representative of the aquifer in contact with the well screen is being sampled is to perform a controlled sampling experiment. When indicator parameters such as specific conductance, pH, temperature, turbidity, and dissolved oxygen are stabilized, the well is presumed to be adequately flushed for the representative sample. In some instances, purging rates must be kept below 5 gal/min to avoid overpumping or pumping the well to dryness. Ideally, wells should never be pumped to dryness. To accomplish this, pump rates may be adjusted, sometimes to less than 1 gal/min, and pumping times extended. Pumping with low flow rates may also reduce the need for filtering water samples. Purging or

evacuation of the well can be accomplished in several ways. In any instance it is paramount to ensure that the purging procedure does not cause cross-contamination from one well to the next. Therefore, the preferred method employs dedicated equipment and pumps. Because in many cases it may not be practicable to dedicate a pump to a specific well, it is permissible to decontaminate this equipment, using approved methods. Tubing should always be dedicated and never used for more than one well. The selection of an evacuation method most often relies on the depth to water (DTW) in the well. If the static DTW is less than 25 ft, a hand pump or bailer may be the best method for evacuation. If the static DTW is greater than 25 ft, a submersible pump should be used. As mentioned earlier, care must be used to ensure that this does not act as a route of cross-contamination. Pumps should be decontaminated between well locations. During evacuation, pump intake must not be set greater than 6 ft below the dynamic water level. This requires that the evacuation device be lowered as purging continues and the water level drops. Hand bailing may be utilized with a static water level greater than 25 ft if a submersible pump is not available or with a static water level less than 25 ft if other conventional pumps are not available. However, this is not recommended for reasons such as the potential to aerate the well water, inadequate removal of fines, a concentration of floating product on the bailer that may introduce contamination, potential to introduce contaminants from inside of the well casing, and non-steady removal of water, which may result in dilution instead of evacuation of the well. In general, the mechanics of the hand-bailing method for well purging may introduce contamination potential and variability. There are many pumps that may be used for well purging. Not all pumps are acceptable under all conditions. The preferred and most commonly used pumps are centrifugal and peristaltic pumps (when depth to water is less than 25 ft) and submersible pumps (when depth to water is greater than 25 ft). Information on various pumps and methods of purging is provided later in this instruction. Recent studies have found that some in situ groundwater sampling devices minimize or eliminate the need for purging EPA/600/54-90/028. Occasionally, a non-aqueous phase layer (NAPL) (floating product) may be present in a monitoring well designated for sampling. If it is suspected that the well contains an NAPL, an interface probe should be used to verify its presence. If an NAPL is present, the thickness should be measured and an appropriate inert bailer should be used to collect a sample of the product. Collection of a groundwater sample may not be appropriate if an NAPL is known to be in the well.

(2) Bailers. Bailers are one of the simplest and most commonly used sampling methods for sampling groundwater monitoring wells (Figure C-1).

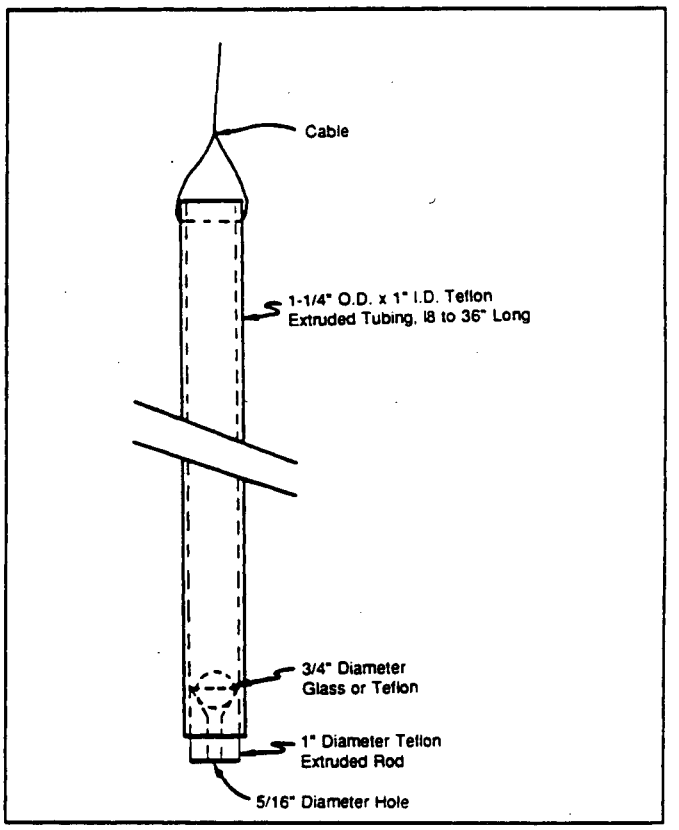


Figure C-1. Bailer

(a) Applicability. Bailers are constructed of a wide variety of materials compatible with the parameter of interest. They are economical and convenient enough that a separate bailer may be dedicated to each well to minimize cross-contamination. An external power source is not required. Bailers provide a low surface-to-volume ratio, which reduces degassing of volatile organic compounds (VOCs). Cross-contamination can be a problem if the bailer is not adequately decontaminated. Bailers offer a relatively limited sample volume and may not be desirable for purging a well if large amounts of water need to be removed from the well for purging purposes. Bailers may also cause a surging action on the well, which may increase the turbidity of the well sample.

(b) Method summary and equipment. Bailers are one of the simplest and most commonly used sampling methods for groundwater wells. Bailers are manufactured in

numerous types, sizes, and construction materials. Bailers are typically weighted lengths of pipe attached to a cord with a check valve at the lower end. They are typically constructed of PVC, PTFE, or stainless steel. The PTFE bailer is recommended for collecting groundwater samples for VOC analysis. Bailers can be dedicated to a specific well, i.e., used only for purging and sampling that well. Dedicated bailers are typically stored to prevent cross-contamination or, less preferably, left hanging in the well itself. The bailer should be decontaminated after each use, regardless of whether the bailer is dedicated to one well or used to sample other wells. Disposable bailers are also available and are cost-effective for certain investigations. Haul-lines for bailers may consist of PTFE-coated stainless steel cable, polyethylene rope, or nylon rope. Of these three, nylon rope is the least desirable because it may introduce contaminants. The use of braided rope is discouraged, because it cannot be decontaminated. For each sampling event, the rope for dedicated bailers should be changed following purging and prior to sampling. For nondedicated bailers, rope should be changed between wells. After removal, the rope should be properly discarded.

(c) Sampling procedure.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging purposes.
- Attach decontaminated bailer to cable or line for lowering or use dedicated bailer already in well.
- Lower bailer slowly until it contacts water surface.
- Allow bailer to sink and fill with a minimum of surface disturbance.
- Slowly raise bailer to surface. Do not allow bailer line or bailer to contact ground.
- Purge well until the pH, temperature, and specific conductance are each at equilibrium, and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between each reading.
- Tip bailer to allow slow discharge from top to flow gently down the side of the sample bottle with minimum entry turbulence. If a bottom drain is present on the bailer, it is recommended that a slow steady flow be achieved through the bottom drain.
- Repeat steps 4-8 as needed to acquire sufficient volume to fill all sample containers.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Verify that a PTFE liner is present in cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to include all necessary information.
- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook, field sheet, and complete all chain-of-custody documents (see Instruction F-1, "Documentation," in Appendix F).
- Thoroughly decontaminate the bailer after each use, regardless of whether the bailer is dedicated to one well or used to sample other wells.
- Close well.

(3) Portable submersible pump. Portable submersible pumps are an effective technique for pumping large volumes of water at a steady rate but require an external electrical power source.

(a) Applicability. Advantages of submersible pumps include their ability to pump variable amounts from various depths. This advantage makes these pumps applicable not only for purging and sampling but also for aquifer characterization tests. Pumping rates for various units range from as little as 100 ml per minute to 1,000 gpm. The pumping rate for most units can also be individually adjusted. Disadvantages of submersible pumps are that they require an external electrical power source and may be difficult to decontaminate between wells. The

propeller construction of the pump assembly may cause degassing of volatile organic compounds; therefore, some states or EPA regions may restrict the use of submersible pumps when sampling for VOCs.

(b) Method summary and equipment. For submersible pumps, the pump assembly, the electric drive motor, and associated hoses and electrical cables are suspended from a steel cable or discharge pipe and submerged in the well. Intake is typically located between the motor and the pump assembly. Horsepower, head, and lift capacity range widely. Submersible pumps are available for 2-in. and larger wells. Some pumps are constructed of stainless steel and PTFE to maintain sample integrity. Submersible pumps far exceed the pumping limitations of other sampling equipment.

(c) Sampling procedure. Recommended sampling procedures are discussed below.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the saturated water column in the well using an electronic water level indicator. Calculate fluid volume in the casing and determine the amount of water to be removed for purging purposes.
- Lower the decontaminated pump to below the water level and begin pumping. Collect or dispose of purged water in an acceptable manner. Lower the pump as required to maintain submergence.
- Measure rate of discharge frequently. A bucket and stopwatch are commonly used.
- Purge well until the pH, temperature, and specific conductance are each at equilibrium, and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between readings.
- Reduce the pump discharge rate to less than 500 mL/min. Fill sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as filled.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Ensure that the PTFE-liner is present in cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Complete chain-of-custody documents, field logbook, and field sheet (see Instruction F-1, "Documentation," in Appendix F).
- Pull pump and allow system to drain and decontaminate.
- Close well.

(4) Bladder pump. Bladder pumps employ a closed collection system that eliminates agitation and air or gas contact with the sample (Figure C-2).

(a) Applicability. Advantages of the bladder pump include its ideal design for sampling wells for VOC analysis from wells as small as 2 in. in diameter. The pump can pump water from various depths and at adjustable rates. It can operate in low-yielding wells without the possibility of burning out the pump if the well is pumped dry. The inlet for the pump body is typically at the lower end, thus requiring minimum submergence. Top-ended inlet pumps are also available for floating product recovery. Disadvantages of the bladder pump include its relatively low pumping rate. It also requires an outside power source of compressed air or gas and may be difficult to decontaminate between wells.

(b) Method summary and equipment. The closed system provides the best method available for sampling wells for VOCs. The pump fills through a lower check valve under hydrostatic pressure, collapsing the bladder in the pump body. The bladder is then pressurized with gas or air causing it to expand, thus applying pressure in the pump body. The bladder is pressurized using a control box and air compressor assembly. This in turn closes the lower check valve and forces the contents of the pump body up through the sample line check valve. Venting the bladder will allow the pump to refill and begin

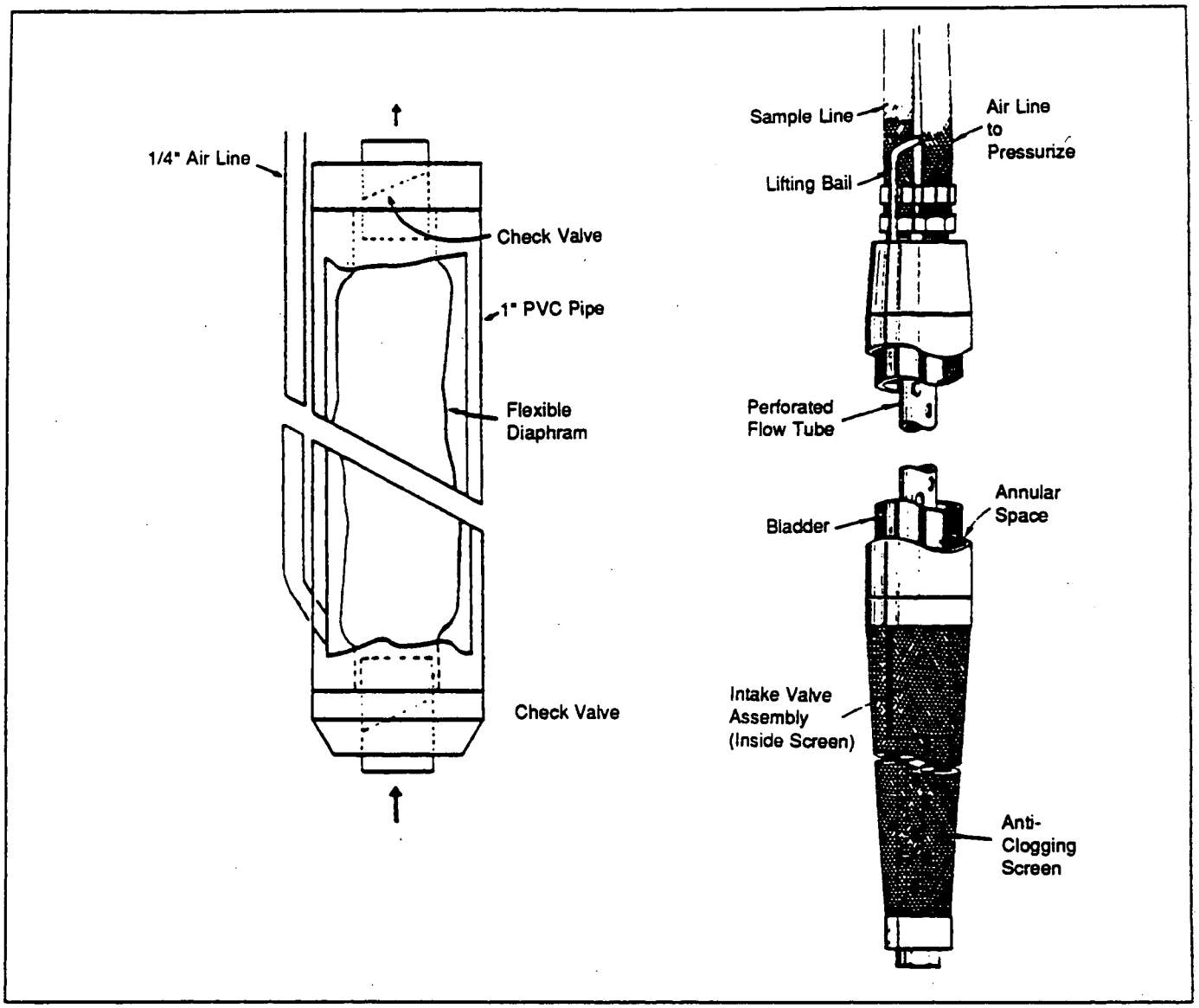


Figure C-2. Bladder pump

another cycle. An inflatable packer is often used in conjunction with bladder pumps to reduce the amount of water to be purged for sampling. The packer is often positioned immediately above the well screen so that only water in the screened area of the well will require purging once the bladder is properly inflated.

(c) Sampling procedure. Recommended sampling procedures are discussed below.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the amount of water to be removed for purging purposes. Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing if an inflatable packer is not present in the well. If an inflatable packer is present in the well, refer to construction diagrams of the well to determine the saturated water column below the packer. Make sure that the packer is not within the screened interval.

- Attach a pressurized air hose to the packer connection (if present) and inflate packer to proper pressurization level, typically 60 to 80 psi. After the packer is inflated, re-attach pressurized air hose to the bladder pump connection and purge the well as discussed above.

- Measure the rate of discharge frequently. A bucket of known volume and a stopwatch are commonly used.

- Purge the well until the pH, temperature, and specific conductance are at equilibrium and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between each reading.

- Fill the necessary sample bottles by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. The pump discharge rate should be less than 500 mL/min. Cap each bottle as filled.

- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

- Check that a PTFE liner is present in cap. Secure the cap tightly.

- Label the sample with an appropriate label. Be sure to complete the label with all necessary information.

- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.

- Complete chain-of-custody documents, field logbook, and appropriate field sheet (see Instruction F-1, "Documentation," in Appendix F).

- De-pressurize packer (if present), remove the pump, and close well.

(5) Hand pumps. Hand pumps are positive displacement pumping systems designed for developing, purging, and sampling (for some analyses) 2-in. or larger groundwater monitoring wells.

(a) Applicability. Hand pumps do not require an external power source. Units are easily transported. A sustained pumping rate can be achieved. The hand pump could cause cross-contamination if the unit is not thoroughly decontaminated. The hand pump may not be suitable for collecting samples for VOCs because the pump creates a vacuum pressure on the water during operation which may result in degassing of volatile compounds.

(b) Method summary and equipment. Hand pumps are readily transportable and can be used to provide sampling in remote areas. Hand operation enables the user to vary the pumping rate to more than 4 gpm at depths exceeding 100 ft. Hand pumps are typically constructed of offset sizes of PVC piping and check valves. Typically, a small diameter pipe resides within a larger diameter pipe. The small diameter pipe is forced up and down and the resulting movement creates a positive displacement.

(c) Sampling procedure. Recommended sampling procedures are discussed below.

- Prepare the work area outside the well by placing plastic sheeting on the ground to prevent cross-contamination.

- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging purposes.

- Lower the decontaminated hand pump assembly into the well and begin operating the pump in a steady motion.

- Measure the rate of discharge frequently. A bucket of known volume and a stopwatch are commonly used.

- Purge the well until the pH, temperature, and specific conductance are each at equilibrium and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between each reading.

- Fill the necessary sample bottles by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. The pump discharge rate should be less than 500 mL/min. Cap each bottle as filled.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.
- Complete chain-of-custody documents, field logbook, and appropriate field sheet (see Instruction F-1, "Documentation," in Appendix F).
- Remove the pump assembly and decontaminate.
- Close the well.

(6) Centrifugal pump. A centrifugal pump is a type of suction pump that is used to purge wells. The centrifugal pump is not suitable for collecting samples for VOC analysis because the pump creates a vacuum pressure on the water during operation, which results in degassing of volatile compounds.

(a) Applicability. Advantages of centrifugal pumps include their ability to provide substantial pumping rates, and their ready availability. Disadvantages are that they require an external power source and may be difficult to decontaminate between wells. The materials with which these pumps are constructed may frequently be incompatible with certain sample analytes. The centrifugal pump is not suitable for collecting samples for VOC analysis because the pump creates a vacuum pressure on the water during operation, which results in degassing of volatile compounds. These pumps cannot pull water more than 20 vertical ft.

(b) Method summary and equipment. Centrifugal pumps are a type of suction pump. An impeller rotating inside the pump chamber discharges water by centrifugal force. The resulting pressure drop in the chamber creates a suction that causes water to enter the intake pipe in the well. Since entrance of water into the intake depends on atmospheric pressure, the height of the intake lift is limited to about 20 ft at sea level and less at higher altitudes. Discharge rates from 5 to 40 gpm can be attained and water can be pushed as high as 150 ft above the pump. Pumps are typically motorized by a small gasoline engine attached to the pump.

(c) Sampling procedure. Recommended sampling procedures are discussed below.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging purposes.
- Lower decontaminated intake hose into well.
- Prime pump with distilled water and start pump.
- Containerize or discharge purge water accordingly.
- Measure the rate of discharge frequently. A bucket of known volume and a stopwatch are commonly used.
- Purge the well until the pH, temperature, and specific conductance are each at equilibrium and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between each reading.
- Collect volatile organic analysis samples, if required, with a bailer.
- Fill sample bottles by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. The pump discharge rate should be less than 500 mL/min. Cap each bottle as filled.
- Preserve the samples as necessary and verify that the pH is sufficient for the criteria.

- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Complete chain-of-custody documents, field sheet, and field logbook. (See Instruction F-1, "Documentation," in Appendix F).
- Close the well.

(7) Peristaltic pump. Peristaltic pumps operate in a manner similar to centrifugal pumps but displace the fluid by mechanical peristalsis (Figure C-3).

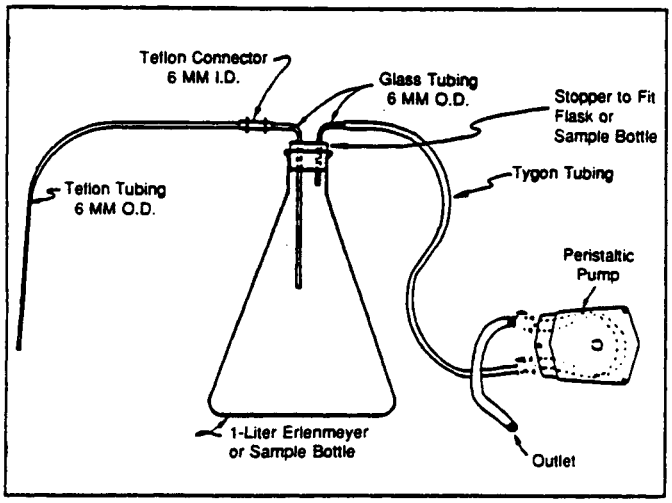


Figure C-3. Peristaltic pump

(a) Applicability. An advantage of the peristaltic pump is its design, which isolates the sample from the moving part of the pump and allows for easy decontamination by removal or replacement of the flexible tubing. Tubing can be dedicated to wells to reduce decontamination time. Disadvantages of these pumps include their low pumping rates and their limited height of intake lift (less than 20 ft). These pumps also require an outside power source and, like other suction pumps, are not suitable for collecting samples for VOC analysis because of potential degassing effects.

(b) Method summary and equipment. A flexible sampling tube is mounted around the pump chamber, and rotating rollers compress the tubing, forcing fluid movement ahead (the peristaltic effect) and inducing suction behind each roller (Figure C-3). Peristaltic pumps generally have very low pumping rates suitable only for sampling shallow water tables in small-diameter wells.

(c) Sampling procedures. Recommended sampling procedures are discussed below.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging purposes.
- Install clean medical grade silicon tubing in the peristaltic pump head and attach the silicon tubing to the glass tubing outlet from the sample bottle.
- Attach the inlet glass tubing from the sample bottle to the required length of new PTFE suction line and lower to the midpoint of the well screen, if known, or slightly below the existing water level.
- Purge the well until the pH, temperature, and specific conductance are each at equilibrium and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between each reading.
- Collect volatile organic analysis samples, if required, with a bailer.
- Fill sample bottles by allowing the discharge to flow gently into the bottle with minimal entry turbulence. Pump discharge should be less than 500 mL/min. Cap each bottle as filled.
- Preserve the samples as necessary and verify that the pH is sufficient for the criteria.
- Verify that a PTFE liner is present in the cap. Secure the cap tightly.

- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.

- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.

- Complete chain-of-custody documents, field sheet, and field logbook (see Instruction F-1, "Documentation," in Appendix F).

- Allow system to drain, then disassemble. Decontaminate or replace tubing for next sampling.

- Close the well.

(8) Air lift pump. Air lift pumps are usually used for developing or purging recovery or extraction wells.

(a) Applicability. Air lift pumps are not recommended for sampling monitoring wells. Because of the contact with well water and the source gas, the sample could be chemically altered. Depending on the source gas, the pH could be altered, oxidation could occur, degassing of VOCs could occur, and lubricating oils from the air compressor could be introduced. Air lift pumps are usually used for developing or purging recovery wells rather than monitoring wells because of their ease of use and their ability to maintain moderate flow rates.

e. Decontamination procedures. All equipment that will enter the well must be decontaminated prior to its entry. The inside surface of pumps and tubing apparatus must be decontaminated by drawing the decontamination solution through the equipment. Field measurement equipment such as water level indicators should be cleaned as described in Instruction E-5 in Appendix E. If the sampling equipment is being prepared for later use, it should be wrapped in cleaned foil. The sampling equipment should remain wrapped in this manner until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time. The requirement for dedicated equipment should apply to all bailers used for collecting samples. Bailers, other sampling equipment, and sample bottles must be physically separated from generators during transport and storage. Decontamination procedures for field equipment are discussed in Instruction E-5 (Appendix E).

f. Field control sample requirements. Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates, and/or background (upgradient) samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 (Appendix H).

g. Documentation requirements. Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and the time of entry recorded. At the end of each day's activity, or entry of a particular event, if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and initial indicating the conclusion of the entry or the day's activity. All aspects of sample collection and handling as well as visual observations, shall be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back once reviewed. Documentation should include:

(1) Project name.

(2) Sampling locations.

(3) Date and times.

(4) Sampling personnel present (identify responsibilities, if applicable).

(5) Level of personal protection equipment worn.

(6) Weather or any environmental condition which may affect the samples.

(7) Equipment utilized.

(8) Calibration data for field screening instruments.

(9) Water quality parameters (i.e., pH, temperature, specific conductance, and dissolved oxygen) taken during development, purging, or sampling.

(10) Deviations to the approved workplans/SAP.

(11) A sketch of the sampled area (denoting sample numbers to locations).

(12) Notating of the system for identifying and tracking all samples taken to their associated QC samples.

(13) Visitors to the site.

(14) Investigation, initials, and date on each page.

(15) Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks should be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sampling form containing the information previously discussed can be developed and used in lieu of a field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should also be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

C-3. Surface Water Sampling

a. Scope of application. Instructions presented in this section are for collecting representative surface water samples from surface water bodies. Surface water bodies can be classified into two primary types: flowing and standing. Flowing bodies include industrial effluent, municipal wastewater, rivers, sewers, leachate seeps, streams, or any other lotic water body. Standing bodies include lagoons, ponds, nonaqueous (e.g., surface impoundments), lakes, or any other lentic water body. Surface water samples can be collected from various depths of the water bodies using some of the techniques described in this chapter. Instructions for sampling surface water bodies using the following techniques are included in this section: hand-held bottle, dipper, pond sampler, peristaltic pump, Kemmerer sampler, weighted bottle, and Bacon bomb sampler.

b. Sampling strategies. Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed for a particular site will influence several project decisions, including but not limited to sampling locations, types of samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels, and the problems associated with trace level cross-contamination. A more detailed discussion of the issues to consider when developing sampling strategies is presented in other USACE guidance. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme to characterize a hazardous waste site should follow the fundamentals of the scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to ambient conditions, vertical extent, horizontal extent, and mobility in various media.

(1) Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to identify contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. However, other factors such as accessibility, sampling equipment requirements, and demands on the sampling team need to be considered when selecting locations. When evaluating a site, sampling can be conducted by random, systematic, or biased sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminant(s), and/or knowledge about the effects of the physical system on the contaminant's fate. Random sampling depends on the theory of random chance probabilities to choose the most representative sample. Often biased and random sampling techniques can be used together to thoroughly address an entire site. Some samples may be biased to potentially contaminated areas (e.g., visually contaminated surface water) or potentially impacted areas (e.g., downstream from discharge pipe). In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Due to the nature of the media, locations for surface water samples are restricted to locations within the water body under evaluation. However, variations of location within the water body may include depth, horizontal location, and time.

(2) Types of samples. The type of sample should be designated when selecting a sampling method. Surface water samples may be discrete or composite samples. A

discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease. Composites are samples composed of two or more specific aliquots (discrete samples) collected at various sampling locations and/or different points in time. Analysis of this type of sample produces an average value and can, in certain instances, be used as an alternative to analyzing a number of individual grab samples and calculating an average value. It should be noted, however, that compositing can mask the presence of contaminants by diluting isolated concentrations of analytes that may be present in the environmental matrix.

(3) Suggested samplers. Each sampling technique presents various disadvantages and advantages for its application. For example, desired depth, tidal influences, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) Sample frequency. Determination of the number of samples needed to characterize a site depends upon sampling objectives and site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. In many cases, statistical considerations can be helpful in determining sampling strategy. It may also be necessary to strategically plan the timing of samples. For example, industrial discharges may be more likely during working hours.

c. Sample preservation and handling. Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in monitoring programs are not chemically stable; therefore, sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical Methods (SW-846).* Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F. Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. Samples should be transferred in the field from the sampling equipment directly into the container that is required for that analysis or set of compatible parameters. The sample should then be preserved in the field as specified in Appendix I. Because of the low analytical detection limits that are required for certain data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. The samples for volatile analysis should be carefully transferred directly from the sample collection device to the sample container in order to minimize contaminant loss through agitation/volatilization or adherences to another container. Samples should be collected in the order of the parameters shown in C-3*c*(1). When more than one container is required per parameter, the sample should be split equally among all containers until filled. Containers used to collect samples for organic analyses should not be prerinsed with water because of the possibility that additional contaminants could adhere to the sample container and taint the analytical results.

(1) Sample containers. When metals are the analytes of interest, high-density or polyethylene containers with PTFE-lined polypropylene caps should be used. (PTFE is commonly referred to using the registered name of Teflon.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Appendix G, "Analytical Techniques/Procedures," contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of precleaned bottles should be verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Refer to Appendix I or the specific analytical method in Appendix G for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

(1) Volatile organics (VOA).

(2) Purgeable organic carbon (POC).

(3) Purgeable organic halogens (POX).

(4) Total organic halogens (TOX).

(5) Total organic carbon (TOC).

(6) Extractable organics.

(7) Total metals.

(8) Dissolved metals.

(9) Phenols.

(10) Cyanide.

(11) Sulfate and chloride.

(12) Turbidity.

(13) Nitrate and ammonia.

(14) Radionuclides.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light. Pre-preserved sample containers should not be used. Because different amounts of preservative may be necessary to bring the sample to the required pH, the USACE policy is to add the preservative to the container in the field. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) Special handling for VOA samples. Water samples to be analyzed for purgeable organic compounds should be stored in 40-mL septum vials with screw caps and like all other samples, a PTFE-silicone disk should be placed in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (PTFE side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program. The 40-mL vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence that could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After the bottle is capped, it should be turned over and tapped to check for bubbles. If any bubbles are present, the procedure must be repeated. Care should be taken to ensure no loss of preservative occurs, if applicable.

(4) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves will be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(c) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(d) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(e) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(f) Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

(g) Collection of adequate field control samples.

d. Sampling methods. Sampling instructions for the most common techniques for collecting surface water samples are presented in this section. Prior to sample collection, water body characteristics (size, depth, flow) should be recorded in the field logbook. Sampling should

proceed from downstream locations to upstream locations so that disturbance related to sampling does not affect sampling quality. When wading in a stream always collect the samples on the upstream side. In addition, if sediment samples are to be collected at the same locations as water samples, the water samples must be collected first. If the project requirements make it necessary to distinguish the concentration of metals in solution from the concentration of metals associated with solids, filtration of the surface water will be required. Filtration techniques are discussed in Instruction E-1 (Appendix E) of this manual. The factors that will contribute to the selection of a sampler include the width, depth, and flow of the location being sampled, and whether the sample will be collected from the shore or a vessel. For flowing liquids an additional concern must be addressed. Tidal influence should be determined and its influence on sample collection should be detailed in the sampling plan. At a minimum, the stage of the tide at the time of sample collection should be recorded. Consideration should be given to sampling at varied tidal stages. Samplers may encounter situations where rate of flow affects their ability to collect a sample. For fast-flowing rivers and streams, it may be nearly impossible to collect a mid-channel sample at a specific point. Low-flowing streams and leachate seeps present the opposite problem. In these cases, the sampler should attempt to find a location where flow is obstructed and a pool is created. If this is not possible, the only way to obtain a sample may be to dig into the sediment with a decontaminated trowel to create a pooled area where the liquid will accumulate. However, this method is not recommended since the sample will probably be highly turbid. If the banks are not sloped, sampling personnel may be able to collect the liquid directly into the sample bottle from the edge of the water body. In some instances where the liquid to be sampled cannot be reached, a pond sampler, by virtue of its extension capabilities, may be necessary. In these cases, the pond sampler should be assembled to ensure that sampling personnel are not in danger of falling into the water body being sampled. For a stream, channel, or river, the sample should be collected at mid-depth. For standing liquid, the sample should be collected just below the surface or at mid-depth. Specific sampling strategies may be altered depending on the contaminants of concern. For instance, when sampling for hydrocarbons or other light nonaqueous phase liquids it may be better to sample at the surface. Once the sample is obtained it should be transferred directly into the sample bottle. The sampling device should be decontaminated before the next sample is taken. If sampling below the water surface is required, some of the samplers discussed below will allow collection of discrete representative liquid samples at various depths. Proper use of the sampling device chosen includes slow lowering and retrieval of the sample, immediate transfer of the liquid into the sampling container, and notation in the logbook of the depth at which the sample was collected.

(1) Hand-held bottle.

(a) Applicability. Filling the sample containers directly is advantageous when the sample might be significantly altered during transfer from a collection vessel into another container. This would affect samples being collected for VOC analysis. The hand-held bottle is not applicable for samples required at depth.

(b) Method summary and equipment. Samples from shallow depths can be readily collected by merely submerging the sample containers.

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.
- Submerge the sample container with the cap in place with minimal surface disturbance so that the open end is pointing upstream.
- Allow the device to fill slowly and continuously using the cap to regulate the speed of water entering the bottle.
- Retrieve the sample container from the surface water with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Verify that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.

- Record the information in the field logbook and complete the chain-of-custody form and field sheets (See Instruction F-1, "Documentation," in Appendix F).

(2) Dippers and pond samplers.

(a) Applicability. Dippers and pond samplers prevent unnecessary contamination of the outer surface of the sample bottle that would otherwise result from direct immersion in the source. Dippers and pond samplers can either be reused or discarded. Discarding the samplers would eliminate the need for decontamination. With the pond sampler, samples can be obtained at distances as far as 10 ft from the edge of the source, preventing the technician from having to physically contact the source. The tubular handle may bow when sampling very viscous liquids if sampling is not done slowly. Dippers and pond samplers perform similar functions, except that the length of the dipper is smaller.

(b) Method summary and equipment. The pond sampler consists of an adjustable clamp attached to the end of a two- or three-piece telescoping aluminum or fiberglass pole that serves as the handle. The clamp is used to secure a sampling beaker (Figure C-4).

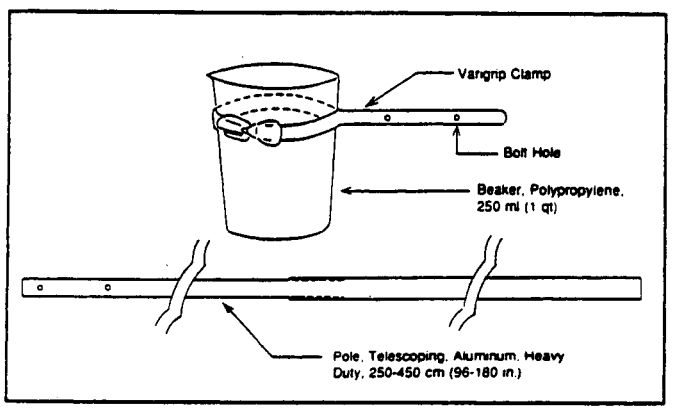


Figure C-4. Pond sampler

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.

- Assemble the dipper or pond sampler. If appropriate, make sure that the sample container and the bolts and nuts that secure the clamp to the pole are tightened properly.

- Collect samples by slowly submerging the precleaned dipper or pond sampler with minimal surface disturbance. Make sure that the open end is pointed upstream.

- Retrieve the dipper or pond sampler from the surface water with minimal disturbance.

- Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper/sampler's edge.

- Empty the sampler slowly, allowing the sample stream to flow gently down the side of the bottle with minimal entry turbulence.

- Continue delivery of the sample until the bottle is filled.

- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

- Check that a PTFE liner is present in the cap. Secure the cap tightly.

- Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.

- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.

- Record the information in the field logbook and complete the chain-of-custody documents and field sheets (See Instruction F-1, "Documentation," in Appendix F).

- Properly clean and decontaminate the equipment prior to reuse or storage.

(3) Peristaltic pump.

(a) Applicability. An advantage of the peristaltic pump is its design, which isolates the sample from the moving part of the pump and allows for easy decontamination by removal or replacement of the flexible tubing. This method can both extend the lateral reach of the sampler and allow sampling from depths below the water surface. Disadvantages of these pumps include their low pumping rates and their limited height of intake lift (less than 20 ft). These pumps also require an outside power

source and, like other suction pumps, are not suitable for collecting samples for VOC analysis because of potential degassing effects.

(b) Method summary and equipment. Peristaltic pumps displace fluid by mechanical peristalsis. A flexible sampling tube is mounted around the pump chamber, and rotating rollers compress the tubing, forcing fluid movement ahead (the peristaltic effect) and inducing suction behind each roller (Figure C-3 in Instruction C-2, "Ground Water Sampling," in this appendix.

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.
- Install clean, medical-grade silicone tubing in the pump head, as instructed by the manufacturer. Attach the silicon tubing to the glass tubing outlet from the sample bottle. (If the sampling device is not constructed as shown in Figure C-3 and the sample bottle is filled directly from the discharge line of the peristaltic pump, the sample will be in direct contact with the intake tubing, the pump head, and the discharge tubing prior to release to the sample container. In this situation, PTFE tubing must be used for the discharge line to avoid cross-contamination of the samples from contaminant leaching that would occur from other "less inert" tubing.)
- Select the length of suction intake tubing necessary to reach the required sample depth and attach it to the intake side of the sample bottle. Heavy-wall PTFE, or a diameter equal to the required pump tubing, suits most applications. (A heavier wall will allow for a slightly greater lateral reach.)
- If possible, allow several liters of sample to pass through the system before actual sample collection. Collect this purge volume and return it to the source after the sample aliquot has been withdrawn.
- Fill the necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as filled.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete the chain-of-custody documents and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Allow system to drain, then disassemble. Decontaminate tubing if necessary, otherwise discard appropriately.

(4) Kemmerer sampler.

(a) Applicability. The Kemmerer sampler is a practical method for collecting discrete, at-depth samples where the collection depth exceeds the lift capacity of pumps. The use of the Kemmerer sampler is limited, however, because it is typically constructed of brass.

(b) Method summary and equipment. The Kemmerer sampler is a messenger-activated water sampling device that is used to sample water from a specific depth (Figure C-5). In the open position, water flows easily through the device. Once lowered to the desired depth, a messenger is dropped down the sample line tripping the release mechanism and closing the container. In the closed position, the bottle is sealed at the top and bottom, isolating the sample during retrieval.

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.
- Inspect Kemmerer sampler to ensure that sample drain valve is closed (if equipped).

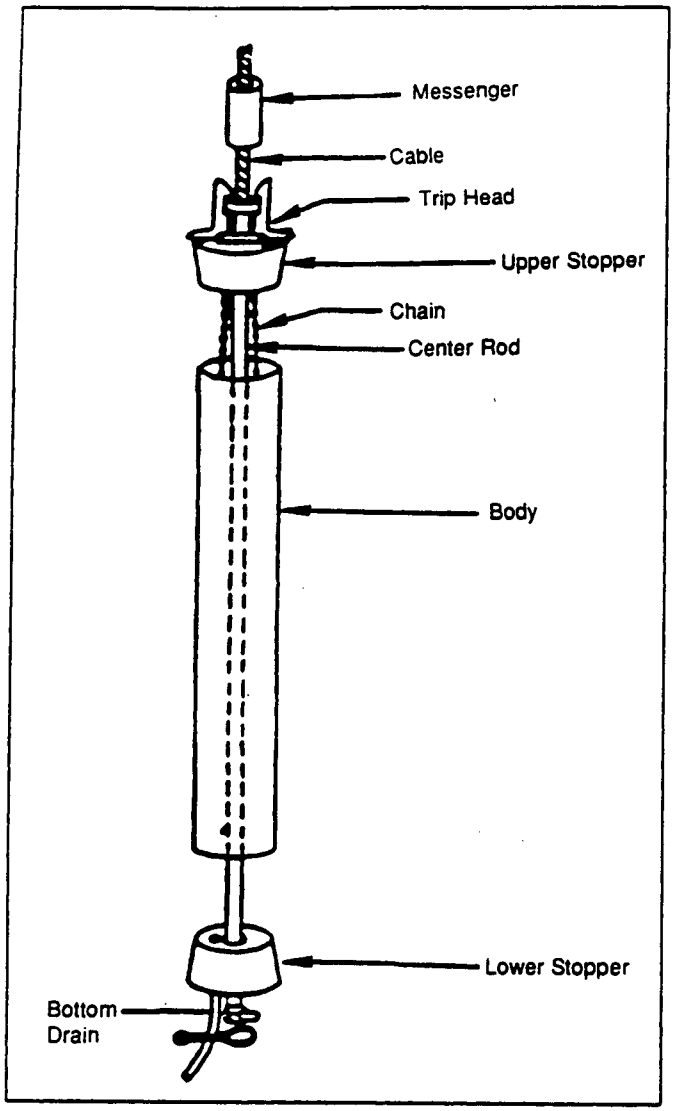


Figure C-5. Kemmerer sampler

- Measure and mark sampler line at desired sampling depth.
- Open bottle by lifting top stopper-trip head assembly.
- Gradually lower bottle until desired sample depth is reached (predesignated mark from Step c).
- Place messenger on sample line and release.
- Retrieve sampler; hold sampler by center stem to prevent accidental opening of bottom stopper.
- Rinse or wipe off exterior of sampler body.
- Recover sample by grasping lower stopper and sampler body with one hand (gloved), and transfer sample by either lifting top stopper with other hand and carefully pouring contents into sample bottles or holding drain valve (if present) over sample bottle and opening valve.
- Allow sample to flow slowly down the side of the sample bottle with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete all chain-of-custody records and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampler.

(5) Weighted bottle.

(a) Applicability. The weighted bottle can be used to obtain samples from a specific depth. The glass construction of the sampler can make the use of this sampler more desirable than the Kemmerer in some sampling situations.

(b) Method summary and equipment. The weighted bottle can be used for collecting representative samples from a specific depth. The sampler consists of a glass bottle, a weighted sinker, a bottle stopper, and a line that is used to open the bottle and to lower and raise the sampler during sampling. Once the sampler is lowered to the desired sampling depth, the stopper is opened, and the bottle is filled and retrieved to the surface.

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment

decontaminated and to prevent cross-contamination.

- Assemble the weighted bottle sampler as shown in Figure C-6.

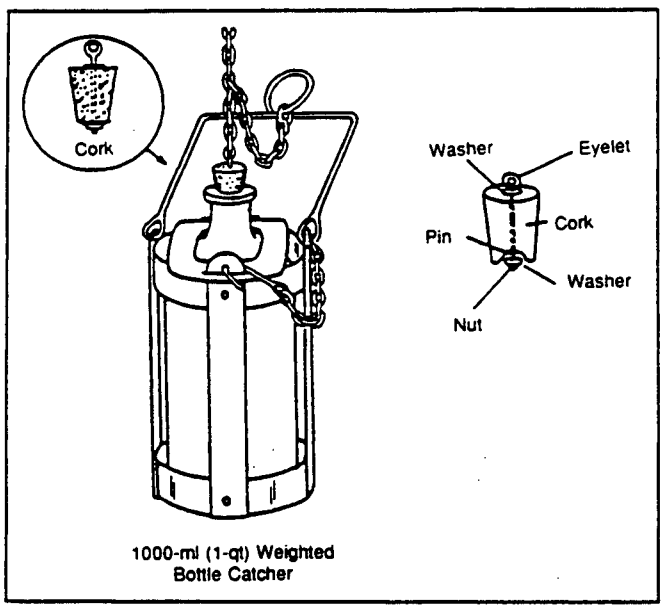


Figure C-6. Weighted bottle

- Measure and mark the sampler line at the desired sampling depth.
- Lower the sampling device to the predetermined depth.
- When the sampler is at the required depth, pull out the bottle stopper with a sharp jerk of the sampler line and allow the bottle to fill completely. (This is usually evidenced by the cessation of air bubbles.)
- Retrieve the sampler.
- Rinse or wipe off the exterior of the sampler body.
- Allow sample to flow slowly down side of sample bottle with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete all chain-of-custody records and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampler.

(6) Bacon bomb sampler.

(a) Applicability. The Bacon bomb sampler is a widely used, commercially available sampler, designed for sampling petroleum products and viscous liquids (Figure C-7). It is very useful for sampling larger storage tanks because the internal collection chamber is not exposed to a product until the sampler is triggered. It is useful in collecting samples at various vertical locations. Like the weighted bottle sampler, the Bacon sampler remains unopened until it reaches the desired sampling depth. The Bacon sampler is difficult to decontaminate and it is difficult to transfer the sample into the sample bottles. The possibility of aerating the sample exists if the sampler does not completely fill with water and air is entrapped in the sampler during retrieval.

(b) Method summary and equipment. The Bacon bomb sampler is constructed of brass or stainless steel and is available in two sizes: 1.5 in. or 3.5 in. in diameter. Samplers range in volume from 4 oz to 32 oz. The Bacon bomb sampler is equipped with a trigger that is spring loaded. When opened, the trigger allows liquid to enter the collection chamber. When the trigger is released, liquid is prevented from flowing into the collection chamber or out of the collection chamber.

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.
- Measure and mark the sampler line at the desired sampling depth.

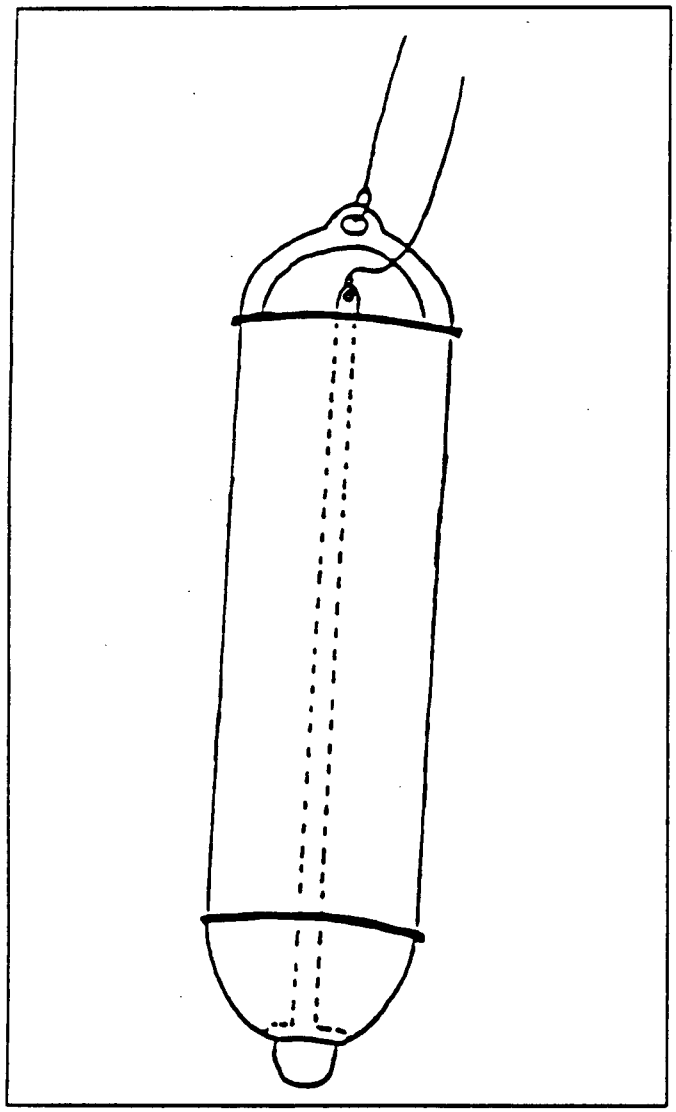


Figure C-7. Bacon bomb sampler

- Lower the Bacon bomb sampler carefully to the desired sampling depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut.
- Release the trigger line and retrieve the sampler.
- Transfer the sample to the sample bottles by pulling on the trigger. Allow the sample to flow down the side of the sample bottle with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete all chain-of-custody records and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate the sampler.

e. Decontamination procedures. All equipment that will enter the water must be decontaminated prior to its entry. The inside surface of pumps and tubing apparatus must be decontaminated by drawing the decontamination solution through the equipment. Sampling equipment should be decontaminated, as described in Instruction E-5 (Appendix E). The sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time. During transport and storage, sampling equipment and sample bottles must be physically separated from engines/generators that are used to power some sampling equipment.

f. Field control sample requirements. Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates, and/or background (upgradient) samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 (Appendix H).

g. Documentation requirements. Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry should be recorded. At the end of each day's activity, or entry of a particular event if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and use his initials to indicate the

conclusion of the entry or the day's activity. All aspects of sample collection and handling, as well as visual observations, should be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back once reviewed. Documentation should include:

(1) Project name.

(2) Sampling locations.

(3) Date and times.

(4) Sampling personnel present (identify responsibilities, if applicable).

(5) Level of PPE worn.

(6) Weather or any environmental condition which may affect the samples.

(7) Equipment utilized.

(8) Calibration data for field screening instruments.

(9) Deviations to the approved workplans/SAP implemented.

(10) A sketch of the sampled area (denoting sample numbers to locations).

(11) Notation of the system for identifying and tracking all samples taken to their associated QC samples.

(12) Notation of any visitors to the site.

(13) Initials and date on each page.

(14) Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks shall be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sampling form containing the information previously discussed can be developed and used in lieu of a field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should also be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initiating the sampling program.

C-4. Potable Water Sampling

a. Scope of application. Instructions presented in this section are for collecting representative potable water (tap water) samples. Discussions are based on the assumption that a supply tap is available for sampling the selected location, for example, a residence. Under this assumption the only applicable sampling method would be the hand-held bottle. The sampling methods discussed in Instruction C-2, "Groundwater Sampling," or C-3, "Surface Water Sampling," should be reviewed if other sampling methods are required for collecting a sample. Discussions presented in this section are a review of the protocols and procedures that should be used when collecting water samples from a tap.

b. Sampling strategies. Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed at a particular site will influence several project decisions, including, but not limited to, sampling locations, type of samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels, and the problems associated with trace level cross-contamination. A more detailed discussion of the issues to consider when developing sampling strategies is presented in other USACE guidance. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme for purposes of characterizing a hazardous waste site should follow the fundamentals of the scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to ambient conditions, vertical extent, horizontal extent, mobility, and contaminant degradation in various media.

(1) Sampling locations. Potable water is usually sampled in an attempt to discover contamination and to define its extent and variability. With such an objective,

it is most logical to choose sample locations that will yield the most information about the water supply system. When evaluating a site, sampling can be conducted by random, systematic, or biased sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminant(s), and/or knowledge about the effects of the physical system on the contaminant's fate. Random sampling depends on the theory of random chance probabilities to choose the most representative sample. Potable water samples may also be collected for evaluating contamination in a particular well or identifying the need for alternate water supply systems. When sampling residential wells, the sample tap should not be located after a household purification system (i.e. water softening or filtration). In these cases an outdoor tap may have to be sampled. Often biased and random sampling techniques can be used together to thoroughly address an entire site. Some samples may be biased to potentially contaminated areas or potentially impacted areas. In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Water taps are stationary and are typically sampled for purposes of evaluating drinking water regulations or contaminant impact on local drinking water supplies. Selection of a sampling location is an investigation objective.

(2) Type of sample. The type of sample should be designated when selecting a sampling method. Potable water samples are typically discrete samples. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected at once and at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease.

(3) Suggested samplers. The sample container is normally used to collect a potable water sample. Use of additional sampling equipment is not recommended. Sample disturbance, sample volume, and chemical/physical reactivity between potential contaminants and the sampling container should be considered when collecting the potable water sample.

(4) Sample frequency. Determination of the number of samples needed to characterize a site is also dependent upon the objectives and site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. Timing for collecting samples may also be crucial. In many cases statistical considerations can be helpful in determining sampling strategy.

c. Sample preservation and handling. Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in potable water monitoring programs are not chemically stable; therefore, sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical Methods (SW-846).* Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F. Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. Samples should be collected in the container that is required for that analysis or set of compatible parameters. The sample should then be preserved in the field as specified in Appendix I. Because of the low analytical detection limits that are required for certain data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. Samples for volatile analysis should be taken in a manner that minimizes contaminant loss through agitation/volatilization. Samples should be collected in the order of the parameters shown in Section C-4*c*(1). When more than one container is required per parameter, the sample should be equally split among all containers until filled. Containers used to collect samples for organic analyses should not be prerinsed with water because of the possibility that additional contaminants could adhere to the sample container and taint the analytical results.

(1) Sample containers. When metals are the analytes of interest, high density polyethylene containers with PTFE-lined polypropylene caps should be used. (PTFE is commonly referred to using the registered name of Teflon.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Appendix G, "Analytical Techniques/Procedures Instructions," contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of precleaned bottles should be

verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Refer to Appendix I or the specific analytical method in Appendix G for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

(a) Volatile organics (VOA).

(b) Purgeable organic carbon (POC).

(c) Purgeable organic halogens (POX).

(d) Total organic halogens (TOX).

(e) Total organic carbon (TOC).

(f) Extractable organics.

(g) Total metals.

(h) Dissolved metals.

(i) Phenols.

(j) Cyanide.

(k) Sulfate and chloride.

(l) Turbidity.

(m) Nitrate and ammonia.

(n) Radionuclides.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, retard hydrolysis, and reduce sorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light. Pre-preserved sample containers should not be used. Because different amounts of preservative may be necessary to bring the sample to the required pH, the policy of the USACE is to add the preservative to the container in the field. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) Special handling for VOA samples. Water samples to be analyzed for purgeable organic compounds should be stored in 40-mL septum vials with screw caps, and like all other samples, a PTFE-silicone disk should be placed in the cap to prevent contamination of the sample by the cap. Disks should be placed in the caps (PTFE side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program. The 40-mL vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence that could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After the bottle is capped, it should be turned over and tapped to check for bubbles. If any bubbles are present, the procedure must be repeated. Care should be taken to ensure that no loss of preservative occurs, if applicable.

(4) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(c) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples shall be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(d) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(e) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(f) Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

(g) Adequate field control samples should be collected.

d. Sampling methods. When sampling potable water, utmost care must be taken to ensure that samples are representative of the water being sampled. This is important not only from a technical and public health perspective, but also from a public relations standpoint. Poor sampling techniques may result in incorrect results (either not detecting a compound that is present or by contaminating the sample and falsely indicating a compound that is not present). If incorrect results are disclosed to the public, it may be impossible to change public opinion when correct results are reported. As discussed in Appendix C-2, "Groundwater Sampling," potable water wells must be purged before the sample is collected. This procedure ensures that water representative of the formation is sampled. The tap should be opened and allowed to flow until the pH, conductivity, and temperature have reached equilibrium. This procedure ensures that any contaminants that might have entered the area of the tap from external sources have been avoided. If the project requirements make it necessary to distinguish the concentration of metals in solution from the concentration of metals associated with solids, filtration of the potable water sample will be required. Filtration techniques are discussed in Instruction E-1 in Appendix E of this manual. Potable water samples should be representative of the water quality within the household or office under investigation. The sampling tap must be protected from exterior contamination associated with being too close to the sink bottom or to the ground. Contaminated water or soil from the faucet exterior may enter the bottle during the collecting procedure since it is difficult to place a bottle under a low tap without grazing the neck interior against the outside faucet surface. Leaking taps that allow water to flow from around the stem of the valve handle and down the outside of the faucet, or taps in which water tends to run up on the outside of the lip, are to be avoided as sampling locations. Aerator, strainer, and hose attachments on the tap must be removed before sampling. These devices can harbor a bacterial population if they are not cleaned routinely or replaced when worn or cracked. Whenever a steady stream of water cannot be obtained from taps, after such devices are removed, a more suitable tap should be sought. Taps where the water flow is not steady should be avoided because temporary fluctuation in line pressure may cause sheets of microbial growth that are lodged in some pipe section or faucet connection to break loose. A smooth-flowing water stream at moderate pressure without splashing should be obtained. Then, without changing the water flow, which could dislodge some particles in the faucet, the samples can be collected. Occasionally, samples are collected to determine the contribution of transmission pipes, water coolers, water heaters, etc., to the quality of water in private residences, offices, etc. The purpose of these investigations may be to determine if metals, e.g., lead, are being dissolved into the water supply. In these cases, it may be necessary to ensure that the water source has not been used for a specific time interval, e.g., over a weekend or a three- or four-day holiday period. Sample collection may consist of collecting a sample of the initial flush and collecting a sample after the indicator parameters have reached equilibrium. Regardless of the type of sample bottle being used, the bottle cap should not be placed on the ground or in a pocket. Instead, the bottle should be held in one hand and the cap in the other, using care not to touch the inside of the cap. Exercise care not to lose the PTFE liner in certain bottle caps. Contaminating the sample bottle with fingers or permitting the faucet to touch the inside of the bottle should be avoided. Sample bottles should not be rinsed before use. When filling any container, care should be taken not to splash drops of water from the ground or sink into either the bottle or cap. To avoid dislodging particles in the pipe or valve, the stream flow should not be adjusted while sampling. Name(s) of the resident or water supply owner/operator and the resident's exact mailing address, as well as his/her home and work telephone numbers, should always be obtained. This information is required in order that the residents or water supply owner/operators can be informed of the results of the sampling program.

(1) Hand-held bottle.

(a) Applicability. Filling the sample containers directly is advantageous when the sample might be significantly altered during transfer from a collection vessel into another container. This would affect samples collected for VOC analysis.

(b) Method summary and equipment. Samples can be readily collected by directly filling the sample containers.

(c) Sampling procedure. The sampling procedures previously discussed in this paragraph should be addressed, if appropriate. Additional sampling procedures are discussed below.

- Place plastic sheeting on the ground surface to prevent cross-contamination of samples.
- Purge the tap or well until the pH, temperature, and specific conductance are at equilibrium.
- Fill the container slowly and continuously.
- Preserve the sample if necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately, along with the required trip blanks if analyzing for VOCs.
- Record the information in the field logbook and complete the chain-of-custody form and field sheets. (See Instruction F-1, "Documentation," in Appendix F).

e. Field control sample requirements. Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates, and/or background (upgradient) samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 in Appendix H.

f. Documentation requirements. Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event, if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and enter his initials, indicating the conclusion of the entry or the day's activity. All aspects of sample collection and handling, as well as visual observations, shall be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back once reviewed. Documentation should include:

(1) Project name.

(2) Sampling locations.

(3) Date and times.

(4) Sampling personnel present (identify responsibilities, if applicable).

(5) Level of PPE worn.

(6) Weather or any environmental condition which may affect the samples.

(7) Equipment utilized.

(8) Calibration data for field screening instruments.

(9) Deviations to the approved workplans/SAP implemented.

(10) A sketch of the sampled area (denoting sample numbers to locations).

(11) Notation of the system for identifying and tracking all samples taken to their associated QC samples.

(12) Notation of any visitors to the site.

(13) Initials and date on each page.

(14) Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks should be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sampling form containing the information previously discussed can be developed and used in lieu of a

field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

C-5. Sediment Sampling

a. Scope of application. Instructions presented in this section are for collecting representative sediment and sludge samples from surface water bodies. Sediment can be considered as any material that is submerged/saturated (at least temporarily) or suspended in any surface water body. This includes sludges, lake bottom sediments, perennial and intermittent stream sediments, and marine sediments. For discussion purposes, sampling devices are classified into the following categories according to applicability: (1) surface sediments/shallow water (scoop), (2) subsurface sediments/shallow water (hand auger/tube sampler, and hand driven split spoon sampler), (3) surface sediments/deep water (Ponar, Ekman, and Smith-McIntyre samplers), and (4) subsurface sediments/deep water (gravity corer and soil coring device/silver bullet sampler).

b. Sampling strategies. Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed for a particular site will influence several project decisions, including, but not limited to, sampling locations, types of samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels, and the problems associated with trace level cross-contamination. A more detailed discussion of the issues to consider when developing sampling strategies is presented in other USACE guidance. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme for purposes of characterizing a hazardous waste site should follow the fundamentals of the scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to ambient conditions, vertical extent, horizontal extent, and mobility in various media.

(1) Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to discover contamination and to define its extent and variab With such an objective, it is most logical to choose sa ple locations that will yield the most information abo site conditions. When evaluating a site, sampling can be conducted by random, systematic, or biased sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminant(s), and/or knowledge about the effects of the physical system on the contaminants' fate. Random sampling depends on the theory of random chance probabilities to choose the most representative sample. Often biased and random sampling techniques can be used together to thoroughly address an entire site. Some samples may be biased to potentially contaminated areas (e.g., lagoons, former process or disposal areas) or potentially impacted areas (e.g., areas of stressed vegetation, sediment downstream from discharge pipe). In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Due to the nature of the media, locations for collecting sediment samples are restricted to locations within the water body under evaluation. Variations of locations for collecting sediment samples include depth, horizontal location, and time. Depositional patterns should be considered against the sample objectives w deciding the sediment sample locations. These pat differ between standing or flowing bodies of water. Gen erally, for flowing water (e.g., stream or river beds), the depositional areas are normally found inside bends, and downstream of islands or obstructions. Areas directly downstream of the joining of two streams should be avoided because the flows may not immediately mix. For standing water bodies, the center of the mass or a discharge point should be sampled for sediments. As discussed above, selection of sample locations should satisfy investigation objectives.

(2) Types of samples. The type of sample should be designated when selecting a sampling method. Sediment samples can be discrete (grab) or composite. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected at once and at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease. Composites are samples composed of more than one specific aliquot (discrete samples) collected at various sampling locations and/or different points in time. Ana sis of this type of sample produces an average valu can in certain instances be used as an alternative t

analyzing a number of individual grab samples and calculating an average value. It should be noted, however, that compositing can mask the presence of contaminants by diluting isolated concentrations of analytes that may be present in the environmental matrix.

(3) Suggested samplers. Samplers for this medium are dictated significantly by project objectives of surficial versus subsurface samples and site constraints of the water depth. Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) Sample frequency. Determination of the number of samples needed to characterize a site is also dependent upon sampling objectives and site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. In many cases statistical considerations can be helpful in determining sampling strategy.

c. Sample preservation and handling. Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in investigation programs are not chemically stable; therefore, sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical Methods (SW-846).* Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F. Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. When subsequent analysis allows, sediment samples should be collected using a clean stainless steel scoop, spoon, or trowel and placed into a clean stainless steel or other appropriate homogenization container. The sample should be mixed thoroughly to obtain a homogeneous, representative sample prior to placement into the sample container. Refer to Instruction E-2 of Appendix E, for a discussion of homogenization procedures. When compositing of samples collected from different locations or at different times is desired, all components of the composite sample are mixed in the homogenization container before the composite sample is placed in the sample container. Refer to Instruction E-3 of Appendix E for a discussion of compositing procedures. The sample should then be preserved in the field as specified in Appendix I. Because of the low analytical detection limits that are required for certain data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. For example, the samples packaged for volatile analysis should not be homogenized or composited. They should be carefully transferred directly from the sample collection device to the sample container in order to minimize contaminant loss through agitation/volatilization or adherences to another container.

(1) Sample containers. When metals are the analytes of interest, wide mouth glass containers with PTFE-lined polypropylene caps should be used. (PTFE is commonly referred to using the registered name of Teflon.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Appendix G, "Analytical Techniques/Procedures," contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of precleaned bottles should be verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Refer to Appendix I or the specific analytical method in Appendix G for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

(1) Volatile organics (VOA).

(2) Purgeable organic carbon (POC).

(3) Purgeable organic halogens (POX).

(4) Total organic halogens (TOX).

(5) Total organic carbon (TOC).

(6) Extractable organics.

(7) Total metals.

(8) Phenols.

(9) Cyanide.

(10) Radionuclides.

(11) Total solids.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods for sediment samples are generally limited to no headspace in sample container, refrigeration, and/or protection from light. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) Special handling for VOA samples. Samples to be analyzed for purgeable organic compounds should be stored in the containers identified in Appendix I. A PTFE-silicone disk should be in the cap to prevent contamination of the sample by the cap. Disks should be placed in the caps (PTFE side in contact with the sample) in the laboratory prior to the beginning of the sampling program. The sample container should be completely filled to prevent volatilization. There should be no headspace left in the sample jar after filling. The sample jar should be closed as soon as possible after filling.

(4) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(c) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(d) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(e) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(f) Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

(g) Collection of adequate field control samples.

d. Sampling methods. Presented below are sampling instructions for the most common techniques for collecting sediment and sludge samples. For additional information see EM 1110-2-5027, Plumb (1981), and Spigolon (1993). Prior to sample collection, water body characteristics (size, depth, flow) should be recorded in the field logbook. Sampling should proceed from downstream locations to upstream locations so that disturbance from sampling does not affect sampling quality. Additionally, if the surface water samples will be collected at the same locations as sediment samples, the water samples must be collected first. The factors that contribute to the selection of a sampler include the width, depth, flow, and the bed characteristics of the surface water body to be sampled, the volume of sample required, and whether the sample will be collected from the shore or a vessel. In collecting sediment samples from any source, care must be taken to minimize disturbance and sample washing as it is retrieved through the liquid column. Sediment fines may be carried out of the sample during collection if the liquid above is flowing or deep. This may result in collection of a non-representative sample due to the loss of contaminants associated with these fines. While a sediment sample is usually expected to be a solid matrix, the sampler should not place the sample in the bottle and decant the excess liquid. If the sample is collected properly, any liquid in the bottle is representative of sediment conditions. As with liquid sampling, a determination of tidal influence on the surface water body being sampled should be made and the effect of the tide on the sample collection should be detailed in the sampling plan. At a minimum, the stage of the tide at the time of sample

collection should be recorded. Consideration should be given to sampling at varied tidal stages. If liquid flow and depth are minimal and sediment is easy to reach, a trowel or scoop may be used to collect the sediment sample. However, when the liquid above the sediment collection point is either flowing or greater than 6 in. in depth, a corer or other device that eliminates sample washing must be used to collect the sample to minimize washing the sediment as it is retrieved. One of the coring devices listed will allow the collection of an undisturbed core of sediment. It may be necessary to decant standing water from the top of the core. This should be done carefully and prior to transfer to the sample bottle. A decontaminated trowel should be utilized to transfer the sample from the corer directly into the bottle. After collection, the sampling device should be decontaminated before collecting the next sample. In some instances, the dimensions of the surface water dictate that a barge or boat must be used. The device used for sample collection in this case will, again, depend upon the depth and flow of the liquid above the sample location and the bed characteristics of the surface water. Generally trowels or scoops cannot be used in an offshore situation. Instead, cores or dredges are a more efficient means for sample collection. The barge or boat should be positioned upstream (if there is flowing water) of the desired sample location. As the corer or dredge is lowered it may be carried slightly downstream, depending upon the force of the flow. Upon retrieval, the contents of the corer or dredge should be transferred directly into the sample bottle using a decontaminated trowel. Both the corer or dredge and the trowel should be decontaminated before collecting the next sample.

(1) Surface sediments/shallow water: Scoop or trowel.

(a) Applicability. The scoop or trowel method is a very accurate procedure for collecting representative samples. This method can be used in many sampling situations but is limited to sampling exposed sediments or sediments in surface waters less than 6 in. deep. The scoop or trowel sampler is not effective for sampling in waters more than 6 in. deep.

(b) Method summary and equipment. The simplest, most direct method of collecting sediment samples is with the use of a stainless steel scoop or trowel (Figure C-8). A stainless steel scoop or trowel can be used to collect the sample and a stainless steel bowl can be used to homogenize the sample when applicable to the subsequent analysis. The scoop or trowel should not be chrome-plated if metals are contaminants of concern.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Sketch the sample area or note recognizable features for future reference.
- Insert scoop or trowel into material and remove sample. In the case of sludges exposed to air, it may be desirable to remove the first 1-2 cm of material prior to collecting the sample.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Check that a PTFE liner is present in cap. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(2) Surface sediments/shallow water: Tube sampler.

(a) Applicability. Equipment for the tube sampler is portable and easy to use. Discrete sediment samples can be collected efficiently. Disadvantages of the tube sampler include its limited sampling depth and inability to collect sediment samples in water bodies greater than a few feet in depth. The tube sampler may not penetrate gravelly or rocky sediments.

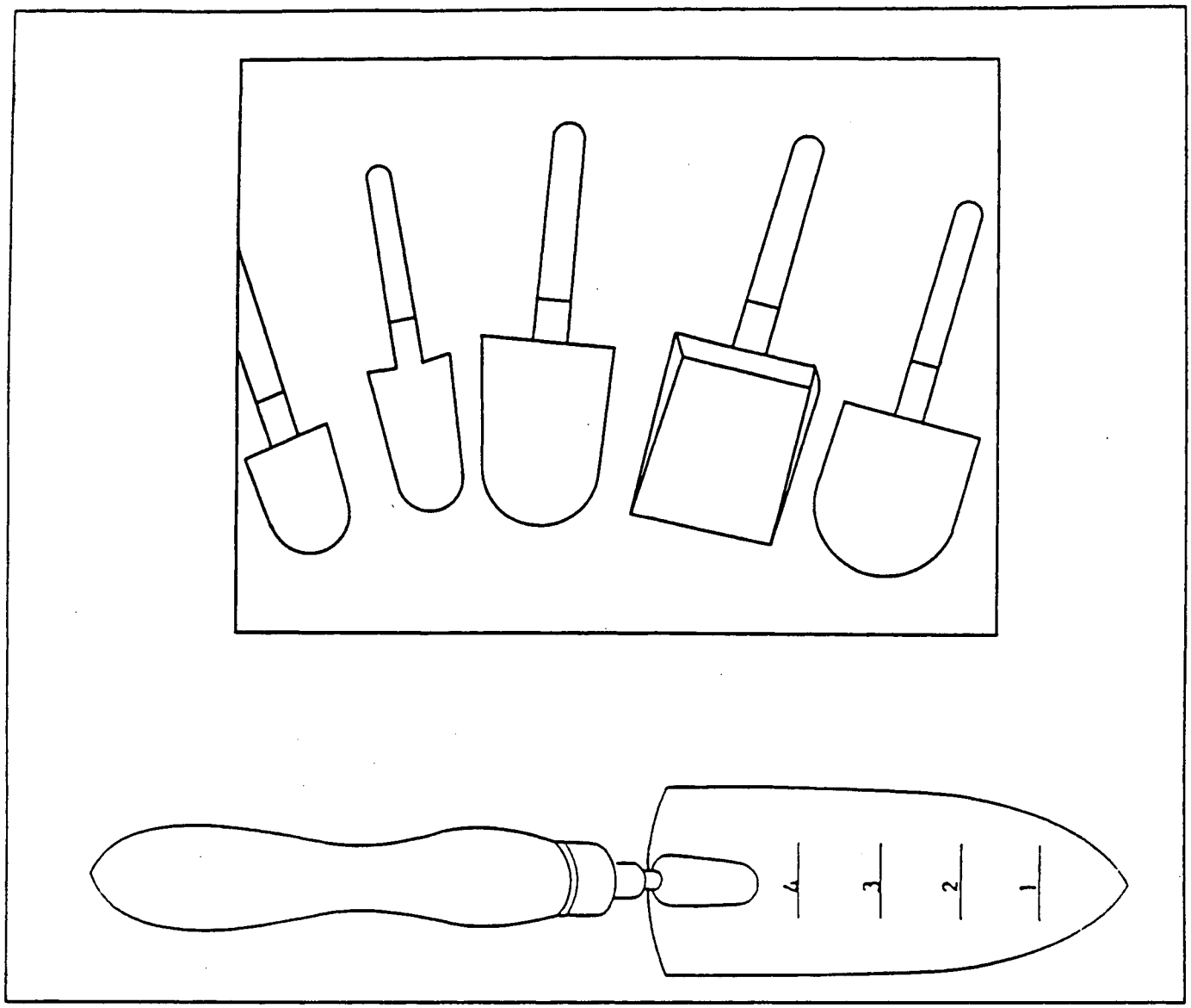


Figure C-8. Scoop trowel

(b) Method summary and equipment. Tube samplers are a simple and direct method for obtaining sediment samples. The corer is forced into the sediment. The corer is then withdrawn and the sample is collected. In non-cohesive soils, sample retention may be a problem. In this case a piston-type sampler is recommended.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Clear the area to be sampled of any surface debris (twigs, rocks, litter).
- Gradually force corer into sediment.
- Remove corer.
- Remove sediment core from corer and place core on a clean working surface.
- Discard top of core if any organic material is present.

- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Repeat steps (3) through (8) as necessary to obtain sufficient sample volume.
- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents, and field sheets and record in the field logbook (See Instruction F-1, Documentation).
- Decontaminate sampling equipment after use and between sample locations.

(3) Subsurface sediments/shallow water: Hand auger and tube sampler.

(a) Applicability. Equipment for the hand auger is portable and easy to use. Discrete sediment samples can be collected efficiently. Disadvantages of the hand auger include its limited sampling depth and inability to collect sediment samples in water bodies greater than a few feet in depth. The tube sampler may not penetrate gravelly or rocky sediments.

(b) Method summary and equipment. Hand augers are a simple and direct method for obtaining sediment samples. Although the maximum sampling depth for the hand auger is typically 5 ft, greater depths can be sampled depending on the sediment type. Hand augers come in various dimensions and various types. The bucket auger bit is used to bore a hole to the desired sampling depth and then withdrawn. The auger tip is then replaced with the tube corer, lowered into the borehole, and forced into the sediment at the desired depth. The corer is then withdrawn and the sample is collected. Potential problems encountered with this method include the collapsing or sloughing of the borehole after removal of the bucket auger. Relocating of the borehole with the tube sampler may also be difficult if the water is turbid.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Attach the auger bit to a drill rod extension and further attach the "T" handle to the drill rod.
- Clear the area to be sampled of any surface debris (twigs, rocks, litter).
- Begin drilling and periodically remove accumulated sediment. This prevents accidentally brushing loose material into the borehole when removing the auger or adding drill rods.
- After reaching the desired depth, slowly and carefully remove the auger from boring.
- Remove auger tip from drill rods and replace with a precleaned or decontaminated thin-wall tube sampler. Install proper cutting tip.
- Carefully lower corer down borehole. Gradually force corer into sediment. Take care to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring because the vibrations may cause the boring wall to collapse.
- Remove corer and unscrew drill rods.
- Remove cutting tip and remove core from device.
- Discard top of core (approximately 2.5 cm), which represents any material collected by the corer before penetration of the layer in question.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.

- Repeat steps (7) through (12) as necessary to obtain sufficient sample volume.
- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets, and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(4) Subsurface sediments/shallow water: Hand-driven split spoon sampler.

(a) Applicability. The split spoon sampler is used for obtaining sediment samples in cohesive and non-cohesive type soils. Similarly to the hand auger, the split spoon sampler can only be used in shallow water. However, because it is hammered into place, it can sometimes penetrate sediments that are too hard to sample with a hand auger.

(b) Method summary and equipment. The split spoon sampler is a 2-in.-diam, thick-walled, steel tube that is split lengthwise (Figure C-9). A cutting shoe is attached to the lower end; the upper end contains a check valve and is connected to the drill rods. For sediment sampling, the split spoon sampler is usually attached to a short driving rod and driven into the sediment with a sledge hammer or slide hammer to obtain a sample.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Assemble the sampler by aligning both sides of barrel and then screwing the drive shoe on the bottom and the heavier head piece on top.

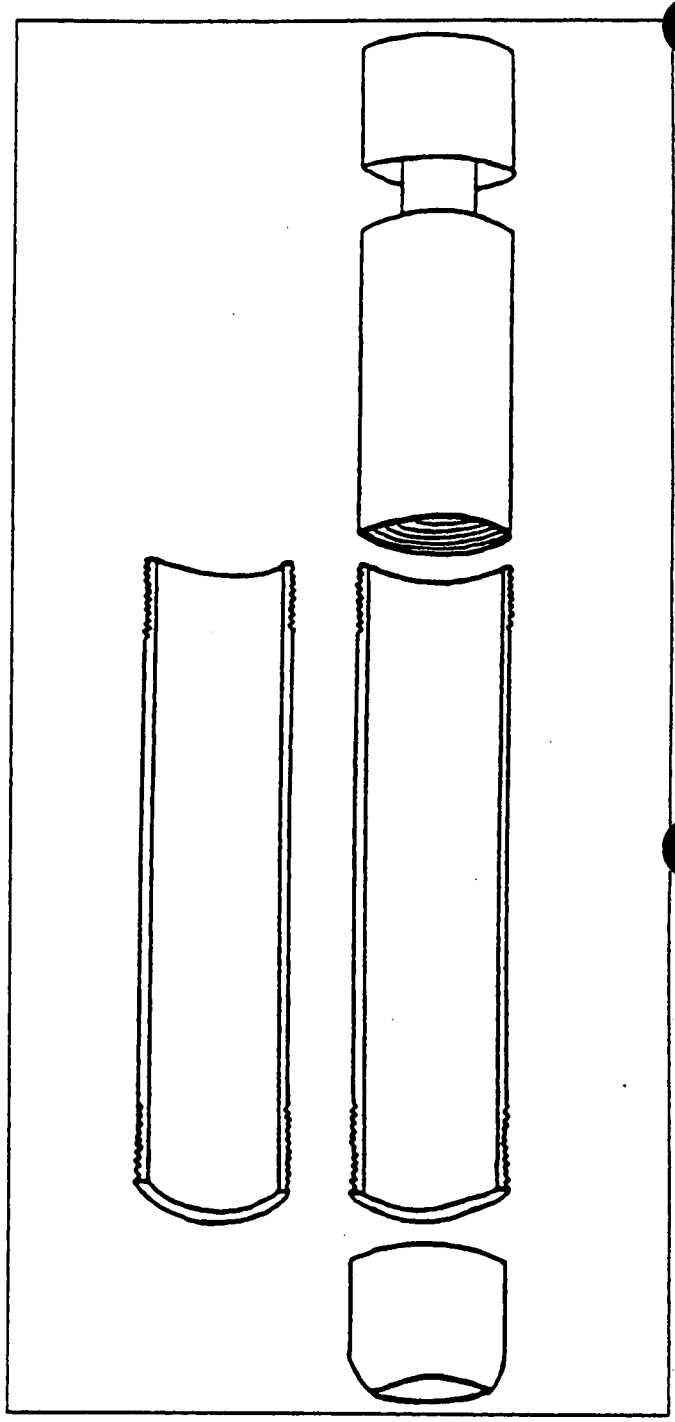


Figure C-9. Standard split spoon sampler

- Place the sampler in a perpendicular position on the material to be sampled.

- Drive the tube utilizing a sledge hammer. Do not drive past the bottom of the head piece as this will result in compression of the sample.
- Record the length of the tube that penetrated the material being sampled and the number of blows required to obtain this depth.
- Withdraw the sampler and open by unscrewing drive shoe and head and splitting barrel. If split samples are desired, a decontaminated stainless steel knife should be utilized to split the tube contents in half longitudinally.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Repeat Steps (2) though (8) until sufficient soil volume has been collected.
- Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets, and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(5) Surface sediments/deep water: Ponar sampler.

(a) Applicability. Ponar samplers are capable of sampling most types of sludges and sediments from silts to granular materials. They are available in hand-operated sizes to winch-operated sizes. Ponars are relatively safe, easy to use, prevent escape of material with end plates, reduce shock waves, and have a combination of the advantages of other sampling devices. Ponar grab samplers are more applicable for a wide range of sediments and sludges because they penetrate deeper and seal better than spring-activated types (e.g., Ekman samplers). Penetration depths will usually not exceed several centimeters. Grab samplers are not capable of collecting undisturbed samples. As a result, material in the first centimeter of sediment cannot be separated from the rest of the sample. Ponars can become buried in soft sediment. The Ponar sampler is not recommended for the acquisition of VOA samples.

(b) Method summary and equipment. The Ponar grab sampler is a clamshell-type scoop activated by a counter-lever system (Figure C-10). The shell is opened, latched in place, and slowly lowered to the bottom. When tension is released on the lowering cable, the latch releases and the lifting action of the cable on the lever system closes the clamshell.

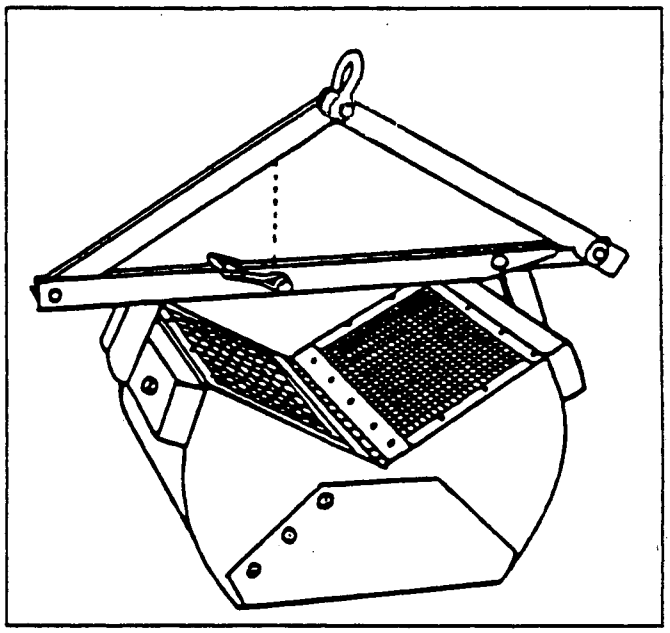


Figure C-10. Ponar sampler

(c) Sampling procedure.

- Place plastic sheeting around the sampling location to prevent cross-contamination.
- Attach a decontaminated Ponar to the necessary length of sample line. Solid braided 5-mm (3/16-in.) nylon - line is usually of sufficient

strength; however, 20-mm (3/4-in.) or greater nylon line allows for easier hand hoisting. ,

- Measure the depth to the top of the sediment with a weighted object.
- Mark the distance to the top of the sediment on the sample line with a proximity mark 1 m above the sediment. Record depth to top of sediment and depth of sediment penetration.
- Open sampler jaws until latched. From this point, support the sampler by its lift line, or the sampler will be tripped and the jaws will close.
- Tie free end of sample line to fixed support to prevent accidental loss of sampler.
- Begin lowering the sampler until the proximity mark is reached.
- Lower the sampler at a slow rate of descent through last meter until contact is felt.
- Allow sample line to slack several centimeters. In strong currents, more slack may be necessary to release mechanism.
- Slowly raise dredge to clear surface.
- Drain free liquids through the screen of the sampler, being careful not to lose fine sediments.
- Place Ponar into a stainless steel or PTFE tray and open. Lift Ponar clear of the tray, and decontaminate.
- Repeat Steps (5) though (12) until sufficient sample volume has been collected.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Collect a suitable aliquot with a stainless steel laboratory spoon or equivalent, and place sample into appropriate sample bottle. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (see Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(6) Surface sediments/deep water: Ekman sampler.

(a) Applicability. The Ekman sampler collects a standard size sample. The Ekman sampler is not useful in rough waters or if vegetation is on the bottom.

(b) Method summary and equipment. The Ekman sampler (Figure C-11) is another type of clamshell-type grab sampler and works similarly to the Ponar sampler described previously. However, because the Ekman sampler is much lighter than the Ponar sampler, it is easier to handle and can even be attached to a pole for shallow applications. The Ekman sampler is unsuitable for sampling, rocky, or hard bottom surfaces.

(c) Sampling procedure.

- Place plastic sheeting around the sampling location to prevent cross-contamination.
- Attach a decontaminated Ekman sampler to the necessary length of sample line or in shallow waters to the end of a pole. Because the Ekman sampler is lightweight, solid braided 5-mm (3/16-in.) mylar line is sufficient.
- Measure the depth to the top of the sediment with a weighted object.
- Mark the distance to top of sediment on the sample line with a proximity mark 1 m above the sediment. Record depth to top of sediment and depth of sediment penetration.

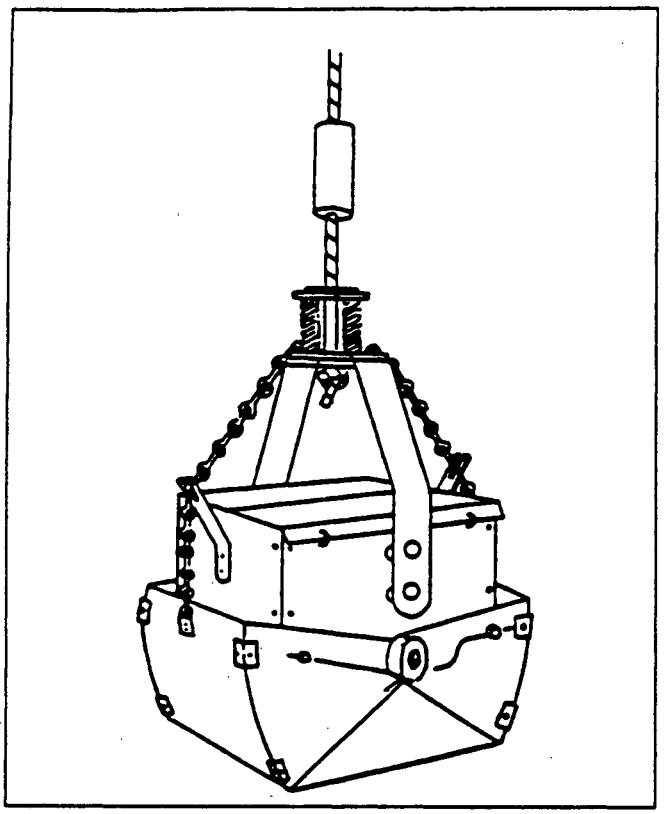


Figure C-11. Ekman sampler

- Open sampler jaws until latched. From this point, support the sampler by its lift line, or the sampler will be tripped and the jaws will close.
- If using a sample line, tie the free end of the sample line to fixed support to prevent accidental loss of sampler.
- Begin lowering the sampler until the proximity mark is reached.
- Lower the sampler at a slow rate of descent through the last meter until contact is felt.
- If using a sample line, place a messenger on the sample line and release, allowing the messenger to slide down to the sample line and activate the spring.
- Slowly raise dredge to clear surface.
- Drain free liquids through the screen of the sampler, being careful not to lose fine sediments.
- Place Ekman sampler into a stainless steel or PTFE tray and open. Lift Ekman sampler clear of the tray and decontaminate.
- Repeat Steps (5) through (12) until sufficient sample volume has been collected.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Collect a suitable aliquot with a stainless steel laboratory spoon or equivalent, and place sample into appropriate sample bottle.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(7) Surface sediment/deep water: Smith-Mcintyre sampler.

(a) Applicability. The Smith-Mcintyre sampler can be used in rough water because of its large and heavy construction. It reduces premature tripping and can be used in depths up to 3,500 ft. The flange on the jaws reduces material loss. It is good for sampling all sediment types. However, because of its large and heavy construction, the Smith-Mcintyre sampler is cumbersome to operate.

(b) Method summary and equipment. The Smith-Mcintyre sampler (Figure C-12) is also a type of clam-shell-style grab sampler and works similarly to the Ponar sampler described previously.

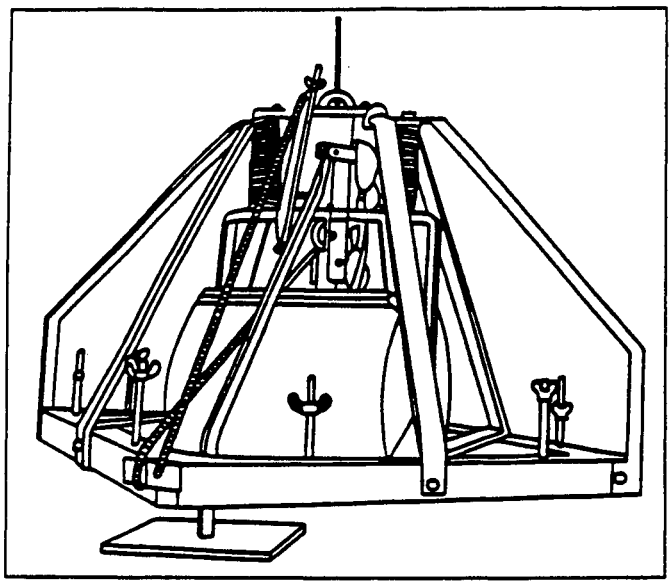


Figure C-12. Smith-Mcintyre sampler

(c) Sampling procedure.

- Place plastic sheeting around the sampling location to prevent cross-contamination.
- Attach a decontaminated Smith-Mcintyre sampler to the necessary length of sample line or in shallow waters to the end of a pole. Because the Smith-Mcintyre sampler is large and heavy, a winch may be necessary for hoisting and lowering the sampler.
- Measure the depth to the top of the sediment with a weighted object.
- Mark the distance to top of sediment on the sample line with a proximity mark 1 m above the sediment. Record depth to top of sediment and depth of sediment penetration.
- Open sampler jaws until latched. From this point, support the sampler by its lift line, or the sampler will be tripped and the jaws will close.
- If using a sample line, tie the free end of sample line to fixed support to prevent accidental loss of sampler.
- Begin lowering the sampler until the proximity mark is reached.
- Lower the sampler at a slow rate of descent through the last meter until contact is felt.
- If using a sample line, place messenger on sample line and release, allowing messenger to slide down the sample line and activate the spring.
- Slowly raise dredge clear to surface.
- Drain free liquids through the screen of the sampler, being careful not to lose fine sediments.
- Place Smith-Mcintyre sampler into a stainless steel or PTFE tray and open. Lift Smith-Mcintyre sampler clear of the tray and decontaminate.
- Repeat Steps (5) through (12) until sufficient sample volume has been collected.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Collect a suitable aliquot with a stainless steel laboratory spoon or equivalent, and place sample into appropriate sample bottle. Secure cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(8) Subsurface sediments/deep water: Gravity corer.

(a) Applicability. Gravity corers are capable of collecting samples of most sludges and sediments. They

collect essentially undisturbed samples that represent the profile of strata which may develop in sediments and sludges during variations in the deposition process. Depending on the density of the substrate and the weight of the corer, penetration to depths of 30 in. can be attained.

(b) Method summary and equipment. The gravity corer is a metal tube with a replacement tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pass through the corer on descent but prevents a washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration. Most corers are constructed of brass or steel and many can accept plastic liners and additional weights.

(c) Sampling procedure.

- Place plastic sheeting around the sampling location to prevent cross-contamination.
- Attach a decontaminated corer to the required length of sample line. Solid braided 3/16-in. nylon line is typically sufficient; 3/4-in. nylon, however, is easier to grab during hand hoisting.
- Secure the free end of the line to a fixed support to prevent accidental loss of the corer.
- Allow corer to free fall through liquid to bottom.
- Retrieve corer with a smooth, continuous lifting motion. Do not bump corer as this may result in some sample loss.
- Remove nosepiece from corer and slide sample out of corer into stainless steel or PTFE pan.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Transfer sample into appropriate sample bottle with a stainless steel lab spoon or equivalent.
- Check that a liner is present in cap. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Thoroughly decontaminate the gravity corer after each use.

(9) Subsurface sediments/deep water: Soil coring device/silver bullet sampler.

(a) Applicability. The soil coring device and the silver bullet sampler are used when a core sample is desired.

(b) Method summary and equipment. The soil coring device consists of a brass cylinder with a handle for turning. The bit of the corer is sharp plastic. A plastic collection tube that will hold a sample is placed on the inside of the brass cylinder. This device may be substituted for the soil auger if core analysis of depth profiles needs to be done. A serious limitation of this instrument is that the depth of the core is only 1.6 ft long. Also, the cutting edge of the coring device is plastic and is unable to pass through very rocky or tightly packed soil. The silver bullet sampler consists of a cylinder into which the sampler is fitted with a T-handle, which is used to manipulate the sampler. The bit is changeable. The silver bullet sampler is designed to take core samples in peat substrates. Due to its design, the sampler lends itself well to uses in hazardous waste sampling. It is versatile and can be used as a soil coring device because the body is adjustable to reach greater depths. Also, the silver bullet sampler has a serrated bit, which allows the sampler to move through rocky or tightly packed substrate more easily.

(c) Sampling procedure.

- Place plastic sheeting around the sampling location to prevent cross-contamination.

- Insert borosilicate collection tube into the sampler.
- Place the sampler in position with the bit touching the ground.
- Press down on the T-handle while rotating the sampler clockwise.
- After reaching the required depth, turn the sampler 360° counterclockwise and remove from the ground taking care not to lose any of the sample.
- Remove the borosilicate glass collection tube and collect sample, or cap at both ends for sample shipment.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Check that a PTFE liner is present in cap. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).

(10) Subsurface sediments/deep water: Vibratory coring device.

(a) Applicability. Vibratory corers are capable of collecting samples of most soils, sediments, and sludges.

(b) Method summary and equipment. The vibratory system consists of a tripod that supports a core tube. An external power source is necessary to drive a top head and cause vibrations. The vibratory motion causes the soil sediments to become fluidized and the core tube to slip through the soil or sediment. For additional information, see U.S. Army Engineer Waterways Experiment Station (1981a, 1981b, 1982, 1993).

(c) Sampling procedure.

- Assemble decontaminated vibratory corer and connect external power source (i.e., air compressor).
- Attach decontaminated corer to the required length or top of the soil or sediment. Begin vibratory coring until the core tube has fully penetrated.
- Carefully remove the core tube and remove the core liner.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place the sample in an appropriate container and put the container on ice.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Thoroughly decontaminate the vibratory corer after each use.

e. Decontamination procedures. All equipment that will enter the sediment must be decontaminated. Sampling equipment should be decontaminated as described in Instruction E-5 (Appendix E). Sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time.

f. Field control sample requirements. Field control samples are collected by the sampling team to determine whether data are of suitable quality. They include blanks,

replicates, and/or background samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 (Appendix H).

g. Documentation requirements. Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and enter his initials indicating the conclusion of the entry or the day's activity. All aspects of sample collection and handling as well as visual observations should be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back, once reviewed. Documentation should include:

(1) Project name.

(2) Sampling locations.

(3) Date and times.

(4) Sampling personnel present (identify responsibilities, if applicable).

(5) Level of PPE worn.

(6) Weather or any environmental condition that may affect the samples.

(7) Equipment utilized.

(8) Calibration data for field screening instruments.

(9) Deviations to the approved workplans/SAP implemented.

(10) A sketch of the sampled area (denoting sample numbers to locations).

(11) Notation of the system for identifying and tracking all samples taken to their associated QC samples.

(12) Notation of any visitors to the site.

(13) Initials and date on each page.

(14) Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks should be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sample form containing the previously described information can be developed and used in lieu of a field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

C-6. Soil Sampling

a. Scope of application. Instructions presented in this section are for collecting representative soil samples. Soil sampling can be classified into two primary types: surficial and subsurface. Bedrock has also been included under this category because most of the equipment used for subsurface soil sampling is also used for rock core sampling. Instructions for sampling surficial and subsurface soils by the following techniques are included in this section: spade and scoop, hand auger and tube sampler, split spoon sampler, ring-lined barrel sampler, thin-walled (Shelby) tube, continuous barrel sampler, and core barrel sampler. EM 1110-2-1907, "Soil Sampling," also addresses these and other types of geotechnical soil sampling which may be adapted for environmental purposes.

b. Sampling strategies. Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed for a particular site will influence several project decisions, including, but not limited to, sampling locations, types of samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels,

and the problems associated with trace level cross-contamination. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme to characterize a hazardous waste site should follow the fundamentals of scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to ambient conditions, vertical extent, horizontal extent, and mobility in various media.

(1) Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to discover contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. When evaluating a site, sampling can be conducted by random, systematic, or biased sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminant(s), and/or knowledge about the effects of the physical system on the contaminant's fate. Random sampling depends on the theory of random chance probabilities to choose the most representative sample. Often, biased and random sampling techniques can be used together to thoroughly address an entire site. Some samples may be biased to potentially contaminated areas (e.g., stained soil, former process or disposal areas) or potentially impacted areas (e.g., areas of stressed vegetation). In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Because of the nature of the media, soil samples can vary considerably across a site. Physical properties of the soil, including grain size and cohesiveness, may limit the depth from which samples can be collected and the method required to collect them. In most soils, hand-powered equipment can only be used to a depth of approximately 4 to 5 ft. At greater depths, soil sampling is normally performed with a drill rig or other mechanically driven device.

(2) Types of samples. The type of sample should be designated when selecting a sampling method. Application techniques for sample methods include discrete (grab) or composite samples. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected immediately and at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease. Composites are samples composed of two or more specific aliquots (discrete samples) collected at various sampling locations and/or different points in time. Analysis of this type of sample produces an average value and can, in certain instances, be used as an alternative to analyzing a number of individual grab samples and calculating an average value. It should be noted, however, that compositing can mask the presence of contaminants by diluting isolated concentrations of analytes that may be present in the environmental matrix. Samples can be collected manually if soil conditions are favorable and the desired depth of sampling is not too great. Manual sampling involves minimal initial cost, and the method is well-suited to a relatively small or specific number of samples. At depths greater than 4 to 5 ft, manual sampling will probably not be possible, and a mechanically driven drilling device will be required. Depending on the sampling requirements of the site, the use of a mechanical drilling device can substantially increase the cost of a sampling investigation. However, it is usually the only method available to obtain soil samples at depths greater than a few feet. There are a great variety of mechanical drilling devices available for soil sampling. Discussions concerning the use of mechanical drilling devices will be limited to the actual tools used to collect the soil samples.

(3) Suggested samplers. Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Subsurface soil conditions themselves will restrict the application of certain samples. For example, the thin-walled tube sampler is not applicable for sampling sands. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) Sample frequency. Determination of the number of samples needed to characterize a site also depends on the objectives and the site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples, from properly chosen locations, will yield useful information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. In many cases statistical considerations can be helpful in determining sampling strategy. Additional guidance concerning sample frequency can be found in other USACE guidance.

c. Sample preservation and handling. Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in soil investigation programs are not chemically stable, and therefore sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical Methods (SW-846).* Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F. Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. When subsequent analysis allows, soil samples should be collected using a clean stainless steel scoop, spoon, or trowel and placed into clean stainless steel or other appropriate homogenization containers. Homogenization procedures are discussed in Instruction E-2 of Appendix E. The sample should be mixed thoroughly to obtain a homogeneous, representative sample prior to placement into the sample container. When compositing samples from different locations or at different times is desired, all components of the composite sample are mixed in the homogenization container before the composite is placed in the sample container. Compositing procedures are discussed in Instruction E-3 in Appendix E. The sample should then be preserved in the field as specified in Appendix I. Because of the low analytical detection limits that are required for certain data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. For example, the samples packaged for volatile analysis should not be homogenized or composited. They should be transferred carefully directly from the sample collection device to the sample container in order to minimize contaminant loss through agitation/volatilization or adherences to another container.

(1) Sample containers. When metals are the analytes of interest, wide mouth glass jar containers with PTFE-lined polypropylene caps should be used. (PTFE is commonly referred to using the registered name of Teflon.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Appendix G, "Analytical Techniques/Procedures Instructions," contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of precleaned bottles should be verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Refer to Appendix I or the specific analytical method in Appendix G for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

(a) Volatile organics (VOA).

(b) Purgeable organic carbon (POC).

(c) Purgeable organic halogens (POX).

(d) Total organic halogens (TOX).

(e) Total organic carbon (TOC).

(f) Extractable organics.

(g) Total metals.

(h) Phenols.

(i) Cyanide.

(j) Radionuclides.

(k) Total solids.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods for soil samples are generally limited to no headspace in the sample container, refrigeration, and/or protection from light. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) Special handling for VOA samples. Samples to be analyzed for purgeable organic compounds should be stored in containers identified in Appendix I. A PTFE-silicone disk should be in the cap to prevent contamination of the sample by the cap. Disks should be placed in the caps (PTFE side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program. The sample container should be completely filled to prevent volatilization. There should be no headspace left in the sample jar after filling. The sample jar should be closed as soon as possible after filling.

(4) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(c) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(d) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(e) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(f) Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

(g) Collection of adequate field control samples.

d. Sampling methods. Presented below are sampling instructions for the most common techniques of collecting soil samples. Prior to sample collection, the soil sampling location and characteristics (soil type, depth) should be recorded in the field logbook. Selection of soil sampling equipment is usually based on the depth of the samples. Manual techniques are usually selected for surface or shallow, subsurface soil sampling. At greater depths, mechanically driven equipment is usually required to overcome torque induced by soil resistance and depth. Additional information on collecting soil samples is presented in EPA/625/R-93/003.

(1) Spade and scoop.

(a) Applicability. The spade and scoop method is a very accurate, representative method for collecting surface and shallow subsurface soil samples. This method is usually limited to soil depths less than 1 ft.

(b) Method summary and equipment. The simplest, most direct method of collecting surface soil samples is to use a spade and stainless steel scoop (Figure C-13). A typical garden spade can be used to remove the top cover of soil to the required depth, and the smaller stainless steel scoop can be used to collect the sample. Typical "garden type" scoops are many times plated with chrome or other metals and would therefore be inappropriate for sampling when analyzing for metals.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Carefully remove the top layer of soil to the desired sample depth with a precleaned or decontaminated spade.
- Using a precleaned or decontaminated stainless steel scoop or trowel, collect the sample aliquot for VOC analysis first, then homogenize enough soil in a stainless steel bowl for the remaining sample containers (see Instructions E-2 and E-3 in Appendix E).
- Transfer sample into the appropriate sample bottle with a stainless steel lab spoon or equivalent.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and record in the field logbook (See Instruction F-1, "Documentation," in Appendix F). Prepare

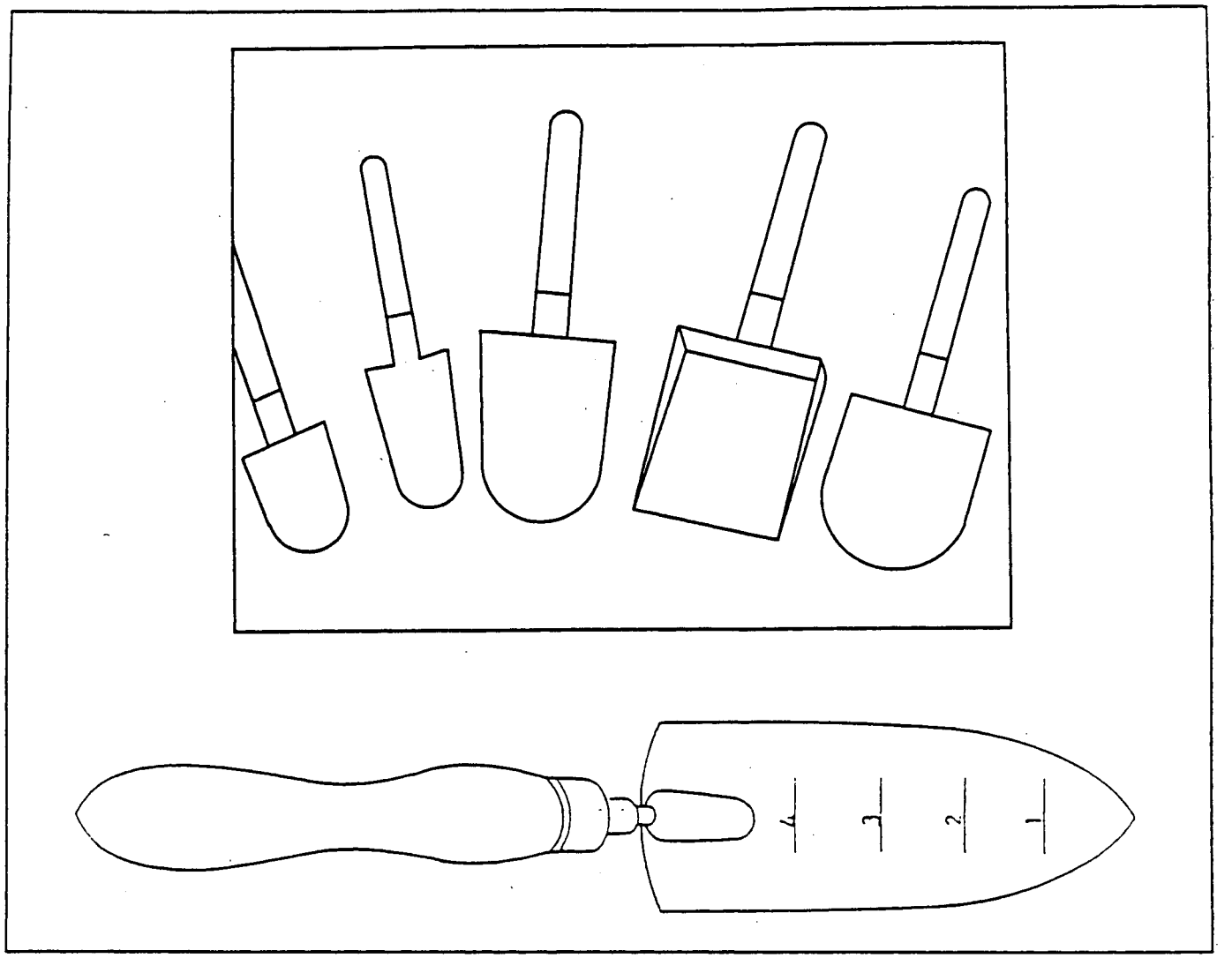


Figure C-13. Spade and scoop

samples for shipment (See Instruction F-2, "Sample Packaging and Shipping," in Appendix F).

- Decontaminate sampling equipment after use and between sample locations.

(2) Hand auger and tube sampler.

(a) Applicability. Equipment for the hand auger is portable and easy to use. Discrete subsurface soil samples can be collected efficiently without the use of a drill rig. Disadvantages of the hand auger include its limited sampling depth. The tube sampler may not penetrate gravelly or rocky soils.

(b) Method summary and equipment. Hand augers are the simplest and most direct method for sampling subsurface soil samples (Figure C-14). Although the maximum sampling depth for the hand auger is typically 5 ft, greater depths can be sampled depending on the soil type. Hand augers come in various diameters and various types. The auger bit is used to bore a hole to the desired sampling depth and then withdrawn. The auger tip is then replaced with the tube corer, lowered into the borehole, and forced into the soil at the completion depth. The corer is then withdrawn and the sample is collected.

(c) Sampling procedure.

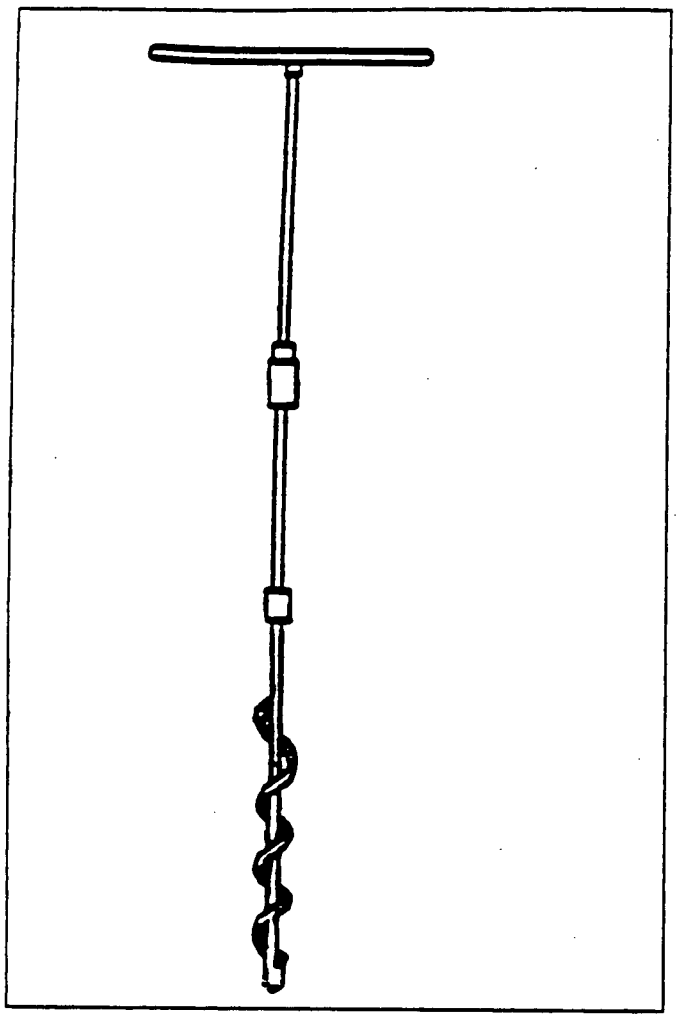


Figure C-14. Hand auger and tube sampler

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Attach the auger bit to a drill rod extension and further attach the "T" handle to the drill rod.
- Clear the area to be sampled of any surface debris (twigs, rocks, litter). It may be advisable to remove the first 8 to 15 cm of surface soil for an area approximately 15 cm in radius around the drilling location.
- Begin drilling, periodically removing accumulated soils. This prevents accidentally brushing loose material into the borehole when removing the auger or adding drill rods.
- After reaching desired depth, slowly and carefully remove auger from boring.
- Remove auger tip from drill rods and replace with a precleaned or decontaminated thin-wall tube sampler. Install proper cutting tip. If non-cohesive materials, (i.e., sands) are being sampled, then it may be necessary to use a bucket hand auger.
- Carefully lower corer down borehole. Gradually force corer into soil. Take care to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring because the vibrations may cause the boring wall to collapse.
- Remove corer by twisting to prevent losing core, and unscrew drill rods.
- Remove cutting tip and remove core from device.
- Discard top of core (approximately 2.5 cm), which represents any material collected by the corer before penetration of the layer in question. Place remaining core into VOA sample container or stainless steel bowl for homogenizing (See Instructions E-2 and E-3 in Appendix E).
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F). Prepare sample for shipment (See Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(3) Split spoon sampler.

(a) Applicability. The split spoon sampler is used for sampling subsurface soil in cohesive and non-cohesive

type soils. It is used extensively for collecting subsurface soil samples for chemical analysis. The split spoon sampler will require a drill rig and crew for collecting samples greater than 5 ft.

(b) Method summary and equipment. The split spoon sampler is typically a 2- or 3-in.-diam, thick-walled, steel tube that is split lengthwise (Figure C-15). If a 2-in. diam split spoon sampler is used, then standard penetration tests can be taken to determine the density of the soil (ASTM 1967). A cutting shoe is attached to the lower end; the upper end contains a check valve and is connected to the drill rods. When a boring is advanced to the point that a sample is to be taken, drill tools are removed and the sampler is lowered into the hole on the bottom of the drill rods. The sampler is driven into the ground in accordance with the standard penetration test.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Assemble the sampler by aligning both sides of the barrel and then screwing the drive shoe on the bottom and the heavier headpiece on top.
- Place the sampler in a perpendicular position on the material to be sampled.
- Drive the tube utilizing a sledge hammer or drill rig if available. Do not drive past the bottom of the headpiece because this will result in compression of the sample.
- Record the length of the tube that penetrated the material being sampled and the number of blows required to obtain this depth. Typically, the number of blows per 6 in. of depth is recorded.
- Withdraw the sampler and open it by unscrewing the drive shoe and head and splitting the barrel. If split samples are desired, a decontaminated stainless steel knife should be utilized to split the tube contents in half longitudinally.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing. Refer to Instructions E-2 and E-3, in Appendix E, respectively.
- Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.

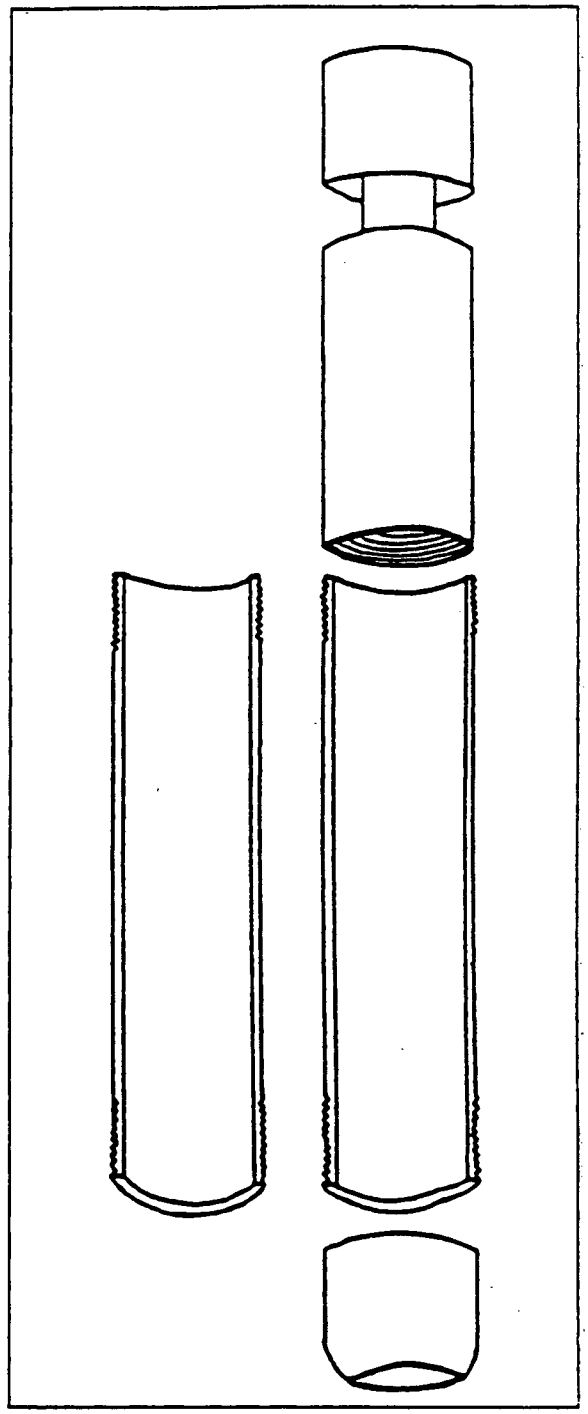


Figure C-15. Standard split spoon sampler

- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to label the bottle carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and record information in field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(4) Ring-lined barrel sampler.

(a) Applicability. The ring-lined barrel sampler provides the ability to collect samples without loosing volatiles or moisture. Soil is contained in the rings and it can be easily and quickly capped after it is removed. The relatively small size of the rings allows easy sample shipping and handling. However, the opportunity for describing the soil is diminished because most of the soil is concealed in the ring apparatus. Since rings are not always accepted by the laboratory, prior arrangements should be made with the laboratory.

(b) Method summary and equipment. Ring-lined barrel samplers are typically 3 in. in diameter and are used to obtain representative subsurface soil samples with a split sampling barrel that has removable rings. The rings are typically constructed of plastic, stainless steel, or brass and fit inside the barrel assembly. Rings are commonly used within the California Modified sampler and are typically 3 in. long.

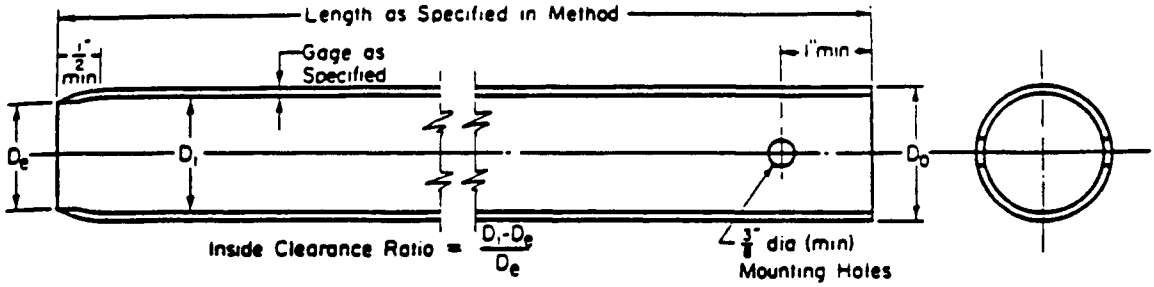
(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Assemble the sampler by placing eight 3-in.-long rings in the 2-ft-long sampler. Align both sides of the barrel and screw the drive shoe on the bottom and the heavier headpiece on top.
- Place the sampler in a perpendicular position on the material to be sampled.
- Drive the tube utilizing a sledge hammer or drill rig if available. Do not drive past the bottom of the headpiece because this will result in compression of the sample.
- Record the length of the tube that penetrated the material being sampled and the number of blows during each 6-in. increment.
- Withdraw the sampler and open it by unscrewing the drive shoe and head and the splitting barrel. Remove the sampling rings. Trim the soil at the end of the rings so that it is flush with the endings. For chemical samples, cap the end of the rings with a PTFE-lined plastic cap. For geotechnical samples, a plastic cap is suitable. Seal each end cap with plastic electrical tape.
- Label the sample ring with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place sealed sample rings on ice immediately.
- Complete all chain-of-custody documents and record information in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(5) Thin-walled (Shelby) tube sampler.

(a) Applicability. Thin-walled tube samplers allow collection of undisturbed samples in cohesive type soils (i.e., clays). They are primarily used for collecting soil samples for certain geotechnical tests. Thin-walled tube samplers are not the ideal container for transporting samples to the laboratory for chemical analysis. The opportunity for describing the soil is diminished because most of the soil is concealed in the tube.

(b) Method summary and equipment. The thin-walled tube sampler is designed to take undisturbed samples in cohesive type soils (Figure C-16). The thin-walled tube sampler is available in either brass, galvanized steel, plain steel, or stainless steel and is manufactured in either 30- or 36-in. lengths. It is available in 2-, 3-, and 5-in. diameters; however, the 3-in. diameter is the most commonly used. Thin-walled tube samplers are usually used



NOTE 1—Minimum of two mounting holes on opposite sides for 2 to 3½ in. sampler.
NOTE 2—Minimum of four mounting holes spaced at 90° for samplers 4 in. and larger.
NOTE 3—Tube held with hardened screws.
NOTE 4—Two-inch outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalents

in.	mm
⅛	6.77
½	12.7
1	25.4
2	50.8
3½	88.9
4	101.6

Figure C-16. Standard thin-walled (Shelby) tube sampler

for sampling cohesive soils for geotechnical evaluation, rather than chemical analysis.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Place the sampler in a perpendicular position on the material to be sampled.
- Push the tube into the soil by a continuous and rapid motion, without impact or twisting. In no instance should the tube be pushed further than the length provided for the soil sample.
- When the soil is so hard that a pushing motion will not penetrate the sample sufficiently for recovery, it may be necessary to collect a disturbed sample with the split-spoon sampler. Extremely dense and hard soils may result in damage to the thin-walled tube sampler.
- Before pulling out the tube, rotate the tube at least two revolutions to shear off the sample at the bottom. For geotechnical analysis, seal the ends of the tube with wax or rubber packers to preserve the moisture content. In such instances, the procedures and preparation for shipment should be in accordance with ASTM Method D1587-83 (ASTM 1983b). For chemical samples, seal the ends of the tube with PTFE-lined plastic caps. Seal each end cap with plastic electrical tape.
- Label the sample tube with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents and record information in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(6) CME (Central Mine Equipment) sampler.

(a) Applicability. The CME sampler provides good samples for describing soil profiles because of the long length of the samples. Discrete samples for chemical analysis can only be collected within a 5-ft increment. This sampler may not be effective in non-cohesive soil types and requires the use of a drilling rig.

(b) Method summary and equipment. The CME sampler is a split barrel sampler that is used in conjunction with the hollow stem auger drilling technique. The sampler is typically 5 ft long and is 4 in. in diameter. The sampler fits inside the lead hollow stem auger and collects soil as the auger is advanced into the soil.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Assemble the sampler by aligning both sides of the barrel and then screwing the drive shoe on the bottom and the heavier headpiece on top.
- Attach the sampler to the drill rod extension and place the sampler inside the lead auger bit.
- Drive the sampler and the lead auger bit utilizing a well rig.
- Withdraw the sampler and open it by unscrewing the drive shoe and head and the splitting barrel. If chemical samples are desired, a decontaminated stainless steel knife should be utilized to divide the tube contents in half longitudinally.
- Transfer the sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.
- Secure the cap tightly.
- Place filled sample containers on ice immediately.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record information in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(7) Core barrel.

(a) Applicability. Core barrel sampling is used primarily for collecting samples for rock profiling purposes. Rock samples are not typically submitted for chemical analysis.

(b) Method summary and equipment. Core barrel drilling is used to obtain samples of rock or soils that are too hard to sample by soil sampling methods. Double tube core barrels work the best. Core bits used for this type of sampling are impregnated with diamonds that cut through the formation allowing a continuous rock sample to be collected.

(c) Sampling procedure.

- Place the core barrel into position with the bit touching the ground or the surface to be cored.
- Continue core drilling until core blockage occurs or until the net length of the core barrel has been drilled.
- Remove the core barrel from the hole and disassemble it as necessary to remove the core.
- Place the recovered core in a core box in accordance with ER 1110-1-1802, and ER 1110-1-1803. The core is placed in the core box with the upper end of the core at the upper left corner of the core box. Cores should be placed in the core box as a book would read, from left to right and top to bottom, within the longitudinal separators. Space blocks or plugs should be placed at the beginning of each core run. Core boxes should be marked on the outside to indicate the top and bottom, and the inside upper left corner of the box should be permanently marked with the letters UL to indicate the upper left corner. Soft or friable cores should be wrapped in plastic film or sealed in wax.

(8) Cone penetrometer rigs.

(a) Applicability. Cone penetrometer rigs have traditionally been used to collect geotechnical data for design of foundations and earth structures. Recent developments have expanded the use of this equipment to the area of

soil and groundwater sampling. Cone penetrometer rigs may also be used to delineate contaminant plumes. EPA/625/R-93/003 discusses the use of a cone penetrometer.

(b) Method summary and equipment. The cone penetrometer rig typically consists of a truck with a fully enclosed work area on the back. Within the work area is a hydraulic ram and computers to record data. The penetrometer collects data by pushing 1.5-in.-diam instrumented probes into the ground. As the probes are pushed they collect data and transmit the data to the onboard computer. This data can be viewed on the computer screen as the probe is advanced, allowing evaluation of the data immediately. The soil sampler used with the cone penetrometer consists of a lined steel cylinder with a retractable tip. The liner (typically a plastic type material) is placed in the sampler and the retractable tip is set at the bottom end of the sampler. The sampler is then advanced to the top of the interval where the soil sample is to be collected. The tip is remotely released and the sampler is pushed ahead into the interval to be sampled. Using this procedure, the soil sampler is pushed to the desired depth and the sample is collected without producing soil cuttings typically generated during soil boring activities. This type of soil sampler can be used with equipment other than cone penetrometers.

(c) Sampling procedure.

- Assemble decontaminated cone penetrometer device that will be pushed into the ground to collect data or samples.
- Push the data collection tip to the desired depth and record the data on the onboard computer. For the soil sampler, advance the sampler to the top of the interval to be sampled, release the tip, and advance the sampler to collect the soil sample.
- While removing the data collection tip, backfill the hole with grout by pumping grout through the tip as it is retracted. Following removal of the soil sample, backfill the hole with grout using the tremie method or by pouring the grout into the hole from the ground surface.
- Remove the liner from the soil sampler and begin sampling with the acquisition of any VOC samples, conducting the sampling with as little disturbance as possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of a different location is desired, the sample is transferred to the stainless steel bowl for mixing. Refer to Instructions E-2 and E-3, in Appendix E, respectively.
- Transfer sample into an appropriate sample bottle using a stainless steel spoon or equivalent.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle. Complete the label completely and clearly, addressing all the categories and parameters.
- Place filled sample containers on ice immediately.
- Complete chain-of-custody documents and field sheets and record in the logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate the equipment following each probe or sample.

(9) Piston sampler.

(a) Applicability. Piston samplers are used to collect soft subsurface soils that cannot be collected using other techniques.

(b) Method summary and equipment. The piston sampler (Figure C-17) consists of a sampling barrel with a piston that is retracted during sampling. Retraction of the piston creates a vacuum within the sample barrel that aids in retaining the sample in the barrel. Various piston type samplers are available, and each should be operated per the manufacturer's recommendations. EPA/625/R-93/003 and EPA/540/8-91/012 discuss the use of a piston sampler.

(c) Sampling procedure.

- Assemble decontaminated piston sampler and attach to rods that will lower the sampler down the borehole.

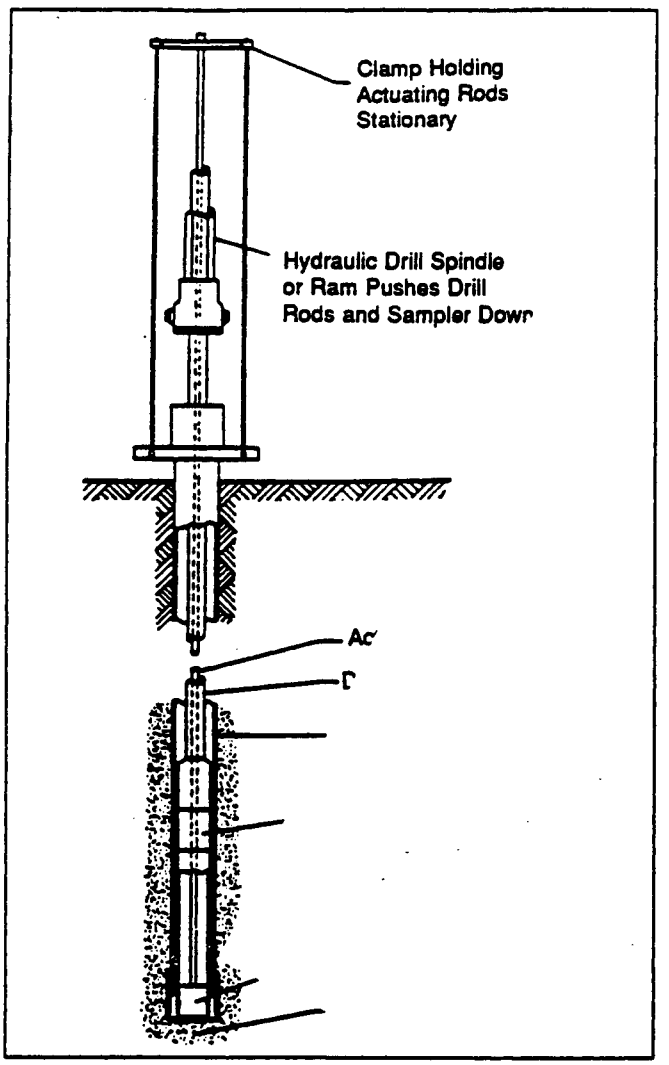


Figure C-17. Piston sampler

- Lower sampler to the desired depth. Advance the sampler into the soil while actuating the piston to create a vacuum within the sample barrel.
- Carefully remove the piston sampler from the bore hole.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to a stainless steel bowl for mixing. Refer to Instructions E-2 and E-3, in Appendix E, respectively.
- Label the sample bottle with the appropriate sample label. Complete the label carefully and clearly, addressing all the categories or parameters.
- Place the sample in an appropriate container and put the container on ice.
- Complete all chain-of-custody documents and field sheets and record in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Thoroughly decontaminate the sampler after each use.

e. Decontamination procedures. All sampling equipment must be decontaminated prior to its use. Sampling equipment should be decontaminated as described in Instruction E-5 (Appendix E). The sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time.

f. Field control sample requirements. Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates, and/or background samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 (Appendix H).

g. Documentation requirements. Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event, if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and use his initials to indicate the conclusion of the entry or of the day's activity. All aspects of sample collection and handling as well as visual observations

should be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back once reviewed. Documentation should include:

(1) Project name.

(2) Sampling locations.

(3) Date and times.

(4) Sampling personnel present (identify responsibilities, if applicable).

(5) Level of PPE worn.

(6) Weather or any environmental condition which may affect the samples.

(7) Equipment utilized.

(8) Calibration data for field screening instruments.

(9) Deviations to the approved workplans/SAP implemented.

(10) A sketch of the sampled area (denoting sample numbers to locations).

(11) Notation of the system for identifying and tracking all samples taken to their associated QC samples.

(12) Notation of any visitors to the site.

(13) Initials and date on each page.

(14) Line out any remaining blank portions or pages with a signature and date.

All entries in field logbooks should be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology that might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sample form can be developed and used in lieu of a field/logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

C-7. Surficial Sampling

a. Scope of application. Instructions presented in this section are for collecting representative samples from various surfaces. Surficial sampling is used to assess the existence and/or extent of contamination on various surfaces rather than in a soil, water, or air matrix. For example, the contamination of the interior of a building may be assessed by collecting wipe samples of the process vessels and ventilation ducts. Surface samples are not typically analyzed for VOCs. Typical sample parameters include polychlorinated biphenyls (PCBs), dioxans/furans, pesticides, semivolatiles, metals, and explosives. Surface samples are typically divided into three media. The media include non-porous surfaces, porous surfaces, and dust/soot. Non-porous surfaces can be sampled by wipe sampling; porous surfaces can be sampled by chipping or coring the surface; and dust/soot can be sampled by sweep sampling. Instructions for these techniques are included in this section. If these methods are difficult to implement due to irregular surface shapes or other limitations, a rinsate sample can be collected.

b. Sampling strategies. The data from surficial sampling is typically required for risk assessments or compliance issues. Therefore, the sampling strategy is either based on a biased approach to locate and/or identify contamination or a systematic approach for decontamination verification.

(1) Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to discover contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. Surficial sampling can be conducted by either biased or systematic sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminant(s), and/or knowledge about the effects of the physical system on the contaminant's fate. Specific requirements for selecting sampling locations may be applicable for risk assessments or verification of cleanup levels. For example, sampling locations for verification of PCB cleanup levels are established in 40 CFR 761. Additional guidance for selecting sampling locations can be found in EPA/600/2-85/028, EPA/560/5-85/026, and EPA/560/586/017.

(2) Types of samples. Surficial samples are discrete samples. Discrete (grab) samples are defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected immediately and at one particular point in the sample matrix. Representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease.

(3) Suggested samplers. Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) Sample frequency. Determination of the number of samples needed to characterize a site also depends on the objectives and the site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. Confirmatory sampling for decontamination or removal actions may warrant specific sample frequency requirements. In many cases statistical considerations can be helpful in determining sampling strategy.

c. Sample preservation and handling. Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in investigation programs are not chemically stable; therefore, sample preservation is required. Chip, core, and sweep samples should be handled in the same fashion as sediment/soil samples. Wipe samples do not designate a preservation technique, but may implement protection from light and/or cooling. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical Methods, SW-846*. Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F.

(1) Sample containers. Wipe samples should be placed in amber jars. The cleanliness of a batch of precleaned bottles should be verified by the container supplier or in the laboratory. The residue analysis should be available prior to sampling in the field.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods are generally limited to refrigeration and protection from light. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) The appropriate template size should be identified. The solvent (including the required grade) in which the contaminants are most soluble should be identified.

(c) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(d) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(e) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc.,

while the other members collect all of the samples. The exact areas sampled should be recorded in the logbook.

(f) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(g) Collection of adequate field control samples. For wipe samples, a blank is mandatory to identify potential interferences from the gauze, solvent, or sample containers.

d. Sampling methods. Presented below are sampling instructions for the most common techniques for collecting surface samples.

(1) Surface wipe sample.

(a) Applicability. This method of monitoring surficial contamination is intended for non-volatile species (e.g., PCBs) on non-porous surfaces (e.g., metal, glass). Sample points should be carefully chosen and should be based on site history, manufacturing processes, personnel practices, obvious contamination, and available surface area.

(b) Method summary and equipment. Surface wipe sampling methods vary and are dependent on the data objectives. A generalized procedure is presented here for reference.

(c) Sampling procedure.

- Place an appropriately sized square template cutout over the area to be sampled (Toxic Substances and Control Act (TSCA) requires 100 cm^2).
- Remove a gauze pad from the box of gauze using decontaminated tongs (filter paper may also be used). Be sure to use a new pair of surgical gloves.
- Soak the gauze or filter pad in appropriate solvent.
- Using a decontaminated pair of tongs, wipe the area framed by the template cutout with the moistened gauze in one direction.
- Without allowing the gauze to contact any other surface, fold the gauze with the exposed side in, and then fold it again to form a 90-degree angle in the center of the gauze.
- Place the gauze in an amber laboratory sample container angle first and replace the container cap.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label properly and clearly, addressing all categories or parameters.
- Place filled sample container on ice immediately, if desired.
- Complete all chain-of-custody documents and record information in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare the samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Mark the area of the cutout using a paint stick, if possible.
- Record the location data, station number, sample time, date, and names of the sampling crew in the field logbook or log sheet for each wipe sample. In addition, document the sampling locations by a dimensioned sketch in the field logbook or log sheet if the sampled area cannot be marked by a paint stick or if locating the area from the field notes would be difficult.
- Dispose of generated waste material properly.

(2) Chip/core sample.

(a) Applicability. This method of monitoring surficial contamination is intended for non-volatile analytes (e.g., PCBs) on porous surfaces (e.g., cement, brick, wood). Suggested sampling points include floors near process vessels, storage tanks, loading docks, etc.

(b) Method summary and equipment. Samples from porous surfaces can be obtained by breaking up a designated surface with a chisel, brushing up the chipped pieces, and transferring the sample into a bottle. A core sample can also be collected using appropriate power tools. However, most confirmatory sampling requires that only the upper quarter inch of the media be sampled. Core samples may dilute contaminants that may only be

present in the upper quarter inch and are therefore discouraged.

(c) Sampling procedure. Once the sample location has been determined, measured, and marked off, sample collection can begin as follows:

- Place an appropriately sized square template cut-out over the area to be sampled.
- Use a decontaminated chisel and hammer to break up the surface to be sampled (TSCA requires 100 cm^2). Avoid scattering pieces. Chip the area to less than 1/4 in. in depth.
- Record the depth at which the chips were taken.
- Collect the chipped pieces using new clean gloves and a pair of decontaminated tongs.
- Transfer the sample directly into the sample bottle.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample container on ice immediately.
- Complete all chain-of-custody documents and record in field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(3) Sweep sample.

(a) Applicability. This method of monitoring surficial contamination is intended for non-volatile analytes (e.g., PCBs) in residue found in porous (e.g., asphalt) or non-porous (e.g., metal) surfaces. Sweep sampling allows collection of dust/residue that may help in the assessment of contaminant determination and delineations.

(b) Method summary and equipment. Dust and residue samples can be collected with a bristle brush and dustpan in places where solvents cannot be used or when large amounts of dust/residue make wipe samples impractical.

(c) Sampling procedure. Once the sample location has been determined, measured, and marked off, sample collection can begin as follows:

- Put on clean, chemical-resistant gloves (separate pair for each location).
- Place an appropriately sized square template cut-out over the area to be sampled (TSCA requires 100 cm^2).
- Sweep all residue from the area to be sampled into the dustpan.
- Transfer the sample directly into the sample bottle.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample container on ice immediately.
- Complete all chain-of-custody documents and record in field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

e. Decontamination procedures. All sampling equipment must be decontaminated prior to its use. Field equipment should be cleaned as described in Instruction E-5 in Appendix E. The sampling equipment should be placed in a plastic bag until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time.

f. Field control sample requirements. Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates and/or background samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the

sampling team for use by the primary laboratory. A detailed discussion of field control samples follows:

(1) Duplicate/split samples. True duplicate/split samples cannot be collected in a wipe sampling program. The gauze used to collect the wipe sample cannot be divided to obtain a duplicate/split sample because the contaminants will not be spread evenly on the gauze. The same surface area cannot be wiped a second time to obtain a duplicate/split sample because the first wipe sample will remove the contaminants from the wiped area. Collecting a sample from an area adjacent to the first sampling area is a viable alternative for collecting a duplicate/split sample. However, the sample is not a true duplicate/split sample and the contaminant concentrations in the samples from the adjacent area may not be the same.

(2) Wipe blank samples. Wipe blanks are samples collected in the field to determine if any interference has been caused by the sample collection materials (i.e., gauze, solvent, or sampling equipment). Wipe blanks are obtained by preparing the gauze for sampling, placing the solvent on the gauze, and placing the gauze in the sample containers. The gauze does not contact any sampling surface.

(3) Background samples. Background samples are recommended to be taken in conjunction with chip/core samples. Background samples should be taken using the same procedures used to obtain the field samples. The samples should be obtained from an uncontaminated area of the same matrix used to collect the field samples. The rationale for collecting background samples is to determine if there are any interferences inherent to the porous matrix.

(4) Rinsate blank samples. Rinsate samples consist of reagent water collected from a final rinse of surfaces after decontamination procedures have been performed. The purpose of the rinsate samples is to determine the thoroughness of the decontamination procedures performed.

g. Documentation requirements. Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and use his initials to indicate the conclusion of the entry or of the day's activity. All aspects of sample collection and handling, as well as visual observations, shall be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back once reviewed. Documentation should include:

- Project name.
- Sampling locations.
- Date and times.
- Sampling personnel present (identify responsibilities, if applicable).
- Level of PPE worn.
- Weather or any environmental condition which may affect the samples.
- Equipment utilized.
- Calibration data for field screening instruments.
- Deviations from the approved workplans/SAP implemented.
- A sketch of the sampled area (denoting sample numbers to locations).
- A photograph log.
- Notation of the system for identifying and tracking all samples taken to their associated QC samples.
- Notation of any visitors to the site.
- Initials and date on each page.
- Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks should be legibly recorded and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project

files. Sample forms may be developed and used in lieu of a field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

Appendix D
Hazardous Waste Sampling Instructions

D-1. Bulk Material Sampling

a. Scope and application. Instructions presented in this section are for collecting representative solid or liquid samples from various containment vessels. These include tanks, drums, waste piles, fiber drums, sacks, bags, and similar small containers. Sampling containerized materials can present unique obstacles to field personnel. Container staging, belowground sampling, identification, and opening are all issues to be considered. Instructions for sampling containerized materials by the following techniques are included in this section: scoop or trowel, waste pile sampler, Veihmeyer sampler/corer, sampling trier, grain sampler, composite liquid waste sampler (COLIWASA), and an open tube sampler. The Bacon bomb sampler described in Appendix C-3 can be used for sampling liquids from large storage tanks.

b. Sampling strategies. Sampling strategies must be geared toward the type of wastes anticipated to be encountered, whether they are above ground or buried, with an important emphasis placed on safety. Safety considerations include the safety of the personnel conducting the work, the surrounding community, and the environment. Occupational Safety and Health Administration standards and regulations should be followed and appropriate monitoring equipment should be used during sampling operations. Sampling strategies are also determined by the stage of the investigation. For instance, during a preliminary assessment of an inventory of containers, it is more appropriate to identify the number of containers present, and take a random sampling of the inventory to identify gross categorization of the waste inventory. The amount of sampling will depend upon the number of total containers and whether there are similar markings on the containers. This information may be used to estimate the cost of cleanup, including the costs involved with transportation, treatment, storage and/or disposal of the wastes. Later stages of the investigation may require sampling and analysis of all the containers individually to identify the waste category and compatibility of the wastes if bulking operations are planned. Often biased and random sampling techniques can be used together to thoroughly address an entire site. Some samples may be biased to potentially hazardous wastes or potentially damaged containers. In containers with low levels of contaminants or containers with little available background information, random samples may be used to allow adequate assessment of the entire site.

(1) Sampling locations. If buried containers (drums, tanks) are investigated, the location of the containers must be determined. Information should be obtained from historical records. Past areal photography of the area may also be helpful in identifying areas that have been filled in over time, or show evidence of stressed vegetation, etc. Geophysical techniques may also be used to locate potential caches of containers. Actual test pit excavations may be made to verify other less conclusive evidence. For drums and other containers which may be staged, locations should be identified for sampling purposes. Typically these areas are temporarily bermed, with sufficient safety and spill cleanup equipment easily accessible. If few containers are encountered and the conditions are secure from a safety standpoint, sampling may be conducted in place. In any kind of container sampling, however, remote operations for handling, staging, and opening are recommended.

(2) Types of samples. All waste samples must be grab samples. Until waste characterization and compatibility testing are completed and confirm that the wastes are compatible, containerized samples should never be composited. Composites are only collected during bulking operations. Normally, bulking operations are conducted to produce a composite sample that is needed to verify the applicability of disposal options. It is important that the composite sample be comprised at the same ratio of the waste to be bulked. It should be noted, however, that composite samples can mask the presence of contaminants by diluting isolated concentrations of analytes that may be present in the environmental matrix.

(3) Suggested samplers and handling equipment. Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Discussions of the advantages and disadvantages of each sampling technique are presented below. Specialized equipment is available for handling drums and other bulk containers. Backhoes equipped with nonsparking bucket teeth and Plexiglas safety cab shields are available for excavating and handling drums and bulk containers. Other excavating and handling equipment includes backhoes with a drum grappler, industrial vacuum loaders, drum lifting yokes, and metal hoists. Special tools used to manually open drums for sampling

include bung wrenches, drum deheaders, hand picks, pickaxes, and hand spikes. Remote devices of opening containers include backhoe spikes, hydraulic drum openers, and pneumatic devices. It is emphasized that remote handling and opening techniques are recommended, especially if the contaminants are not known, or when container integrity is poor.

c. Sample preservation and handling. Bulk samples are considered medium to high concentration samples and are not to be preserved except for cooling and avoidance of light. Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures" in Appendix F and in ER 1110-1-263. Improper sample handling may alter the analytical results of the sample. Samples for volatile analysis should be transferred carefully from the sample collection device to the sample container in order to minimize loss through agitation/volatilization. These samples should not be composited.

(1) Sample containers. When collecting samples from liquids for analysis of metals, high density polyethylene containers with polytetraflouroethylene (PTFE)-lined polypropylene caps should be used. (PTFE is commonly referred to using the registered name of Teflon.) When collecting samples from solids for analysis of metals, wide-mouth glass containers with PTFE-lined polypropylene caps should be used. When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Waste samples should comply with the containers outlined for solid media. Containers should be cleaned based on the analyte of interest. Appendix G, "Analytical Techniques/ Procedures," contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of precleaned bottles should be verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

(a) Volatile organics (VOA).

(b) Purgeable organic carbon (POC).

(c) Purgeable organic halogens (POX).

(d) Total organic halogens (TOX).

(e) Total organic carbon (TOC).

(f) Extractable organics.

(g) Total metals.

(h) Phenols.

(i) Cyanide.

(j) Sulfate and chloride.

(k) Turbidity.

(l) Nitrate and ammonia.

(m) Radionuclides.

(n) Ignitability.

(o) Corrosivity.

(p) Reactivity.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods for samples from bulk containers are limited to refrigeration and protection from light.

(3) Special precautions for bulk and container sampling. Bulk sampling typically involves sampling medium to high level contaminants. Consequently, special precautions are warranted. A phased approach should be used when evaluating bulk containers. The investigation can include all or only parts of the phased approach. Phased tasks for bulk sampling investigations are as follows: reconnaissance, staging, opening, sampling, and packaging. During the reconnaissance phase, visual observations are recorded of container conditions (integrity), any markings, composition of the container, and whether it is an open-top container or a closed-top (bung type) container. Ambient air monitoring should be performed concurrently with these activities. Special precautions should be implemented and segregation of any stainless steel or nickel containers and gas cylinders should be noted, due to the potential for highly reactive, toxic, pressurized, and/or shock sensitive contents. Containers whose integrity is breached should be overpacked immediately, or as soon as possible, to prevent further contaminant migration. Any markings noted on the containers should be

considered suspect and noted for informational purposes only. All bulk container contents should be approached as if they are unknown. Drum staging may be required at sites that have a large number of drums. The purpose of drum staging is to: (a) respond to obvious problems that might impair worker safety; (b) unstack and orient drums for sampling; and (c) if necessary, organize drums into different areas to facilitate characterization and remedial action. Handling may or may not be necessary, depending on how the drums are positioned at the site. Prior to handling the drums, all personnel should be warned about the hazards and instructed to minimize handling the drums as much as possible. In all phases of handling, personnel should be alert for new information about potential hazards and should respond to new hazards before continuing with routine handling operations. Empty overpack drums and an adequate volume of absorbent should be kept near areas where minor spills may occur. Where major spills may occur, a containment berm should be constructed prior to handling the drums. If drum contents spill, personnel trained in spill response should isolate and contain the spill. Remedial and emergency operations may require a separate drum opening area. Procedures for opening drums are the same, regardless of where the drums are opened. Drum sampling can be hazardous to worker health and safety because it can involve direct contact with unidentified wastes. Prior to collecting samples, a sampling plan should be developed that includes: (a) research about the waste; (b) identification of the drums to be sampled; (c) selection of appropriate sampling device(s) and container(s); (d) determination of the number, volume, and locations of samples to be taken; and (e) development of procedures for opening drums, sampling, and sample packaging and transportation. A trained health and safety professional should determine the appropriate personal protection to be used during sampling, decontamination, and packaging of the sample. Worker safety should be maximized during drum opening.

d. Sampling methods. Sampling instructions for the most common techniques of collecting liquid and solids samples from containers are presented below.

(1) Open-ended tube.

(a) Applicability. The method provides a quick, relatively inexpensive means of collecting concentrated wastes. After sampling, the tubing can be discarded, thus eliminating the need for decontamination and the potential for cross-contamination.

(b) Method summary and equipment. Liquid samples from open containers can be readily collected by merely submerging lengths of tubing into the containers (Figure D-1).

(c) Sampling procedure.

- Insert tubing slowly almost to the bottom of the container. Approximately 0.3 m (1 ft) of tubing should extend above the drum. Use the tube to measure any sludge in the bottom of the drum.
- Be sure that the liquid in the container maintains a constant level in the tube during the tube's descent.
- Cap the top of the sampling tube with a tapered stopper or gloved thumb, ensuring that the liquid does not come in contact with the stopper or thumb.
- Carefully remove the capped tube from the container and insert the uncapped end into the sample container, being careful not to spill any liquid outside the container. Removal of the tube from the container may require a step or platform aid.
- Release the stopper or thumb and allow the liquid to drain into the sample container until the appropriate sample containers are filled. Repeat as necessary.
- Remove the tube from the sample container and dispose of properly.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents, drum log sheets and/or record in field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).

(2) Composite Liquid Waste Sampler (COLIWASA).

(a) Applicability. The COLIWASA permits the representative sampling of wastes having a wide range of viscosity, corrosivity, volatility, and solids content. Its simple design makes it easy to use and enables the rapid

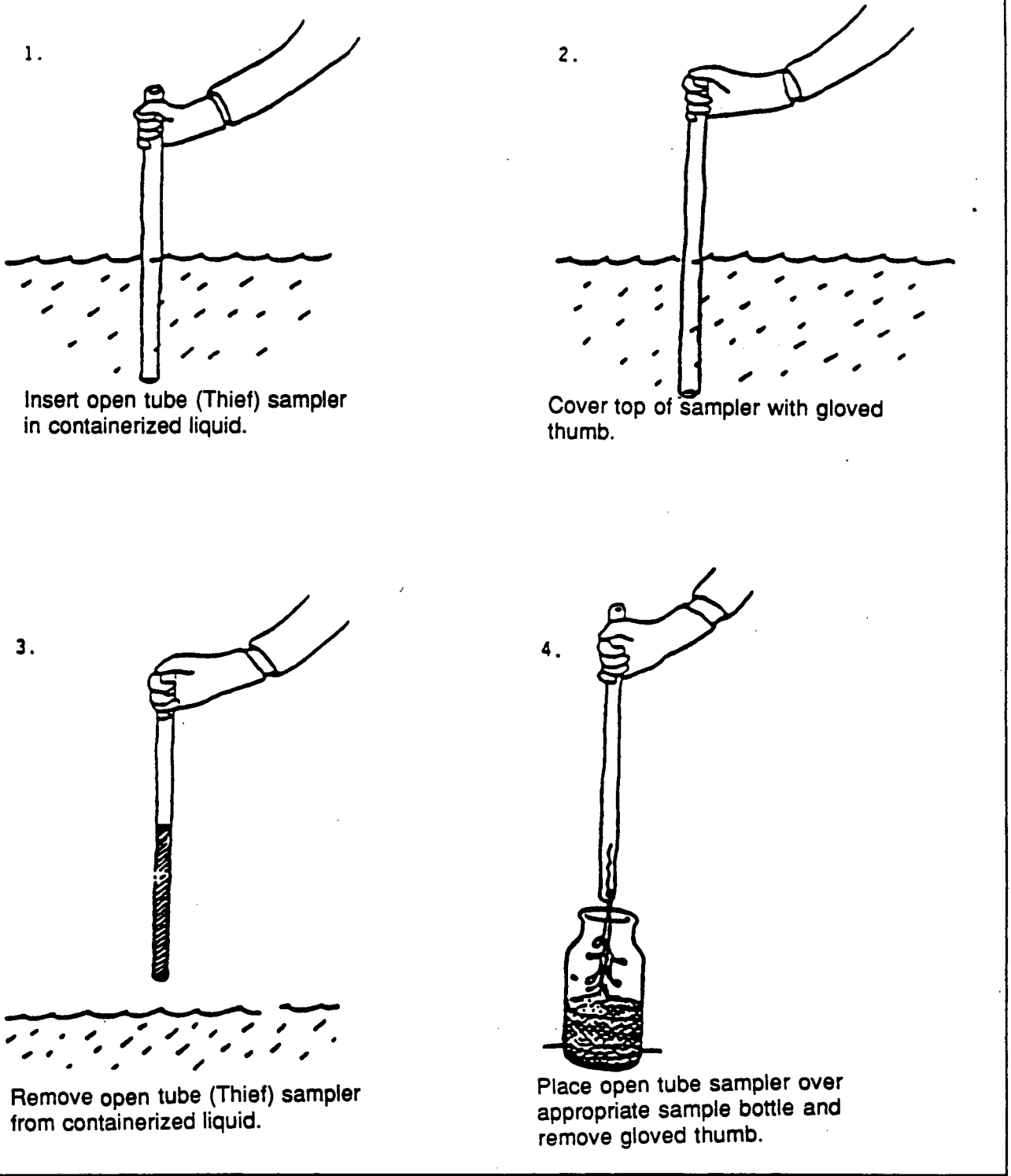


Figure D-1. Open-ended tube sampling procedure

collection of samples, thus minimizing the exposure of the sample collector to potential hazards from the wastes.

(b) Method summary and equipment. A properly constructed COLIWASA can be used to sample very hazardous materials safely and quickly.

(c) Sampling procedure.

- Choose the plastic (Figure D-2) or glass ball type stopper (Figure D-3) COLIWASA for the liquid waste to be sampled and assemble the sampler.
- Ensure that the sampler is functioning properly. Adjust the locking mechanism if necessary to make sure the stopper provides a tight closure.
- Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block. The open position for the glass ball type is achieved by pulling up on the inner rod, thereby pulling the glass ball away from the tapered end of the outer tube.
- Slowly lower the sampler into the liquid waste. (Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sampler tube is lower than the level outside of the sampler, the sampling rate is too fast and will result in a sample biased to bottom contents).
- When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block. The closed position for the glass ball type is achieved by pushing the glass ball end of the inner rod against the tapered end of the outer tube.
- Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.
- Carefully discharge the sample into a suitable sample container by slowly opening the sampler. This is done by slowly pulling the lower end of the T-handle away from the locking block and pulling up on the inner rod to release the contents while the lower end of the sampler is positioned in a sample container. Repeat as necessary.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents, drum log sheets and/or record in field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate the sampling equipment after use and between sampling locations. Since the tube is small and difficult to decontaminate, it may be cost-effective to dispose of the sampler and use new ones for additional sampling.

(3) Scoop or trowel.

(a) Applicability. Stainless steel trowels can be used for sampling soil/solids drums and granular or powdered materials in bins or other shallow containers. The laboratory scoop, however, is a superior choice because it is usually made of materials less subject to corrosion or chemical reactions, thus lessening the probability of sample contamination.

(b) Method summary and equipment. The trowel or scoop can be used to collect shallow samples in a variety of containers (See Figure C-8 in Instruction C-5).

(c) Sampling procedure.

- Insert scoop or trowel into material and remove sample.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters, or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.

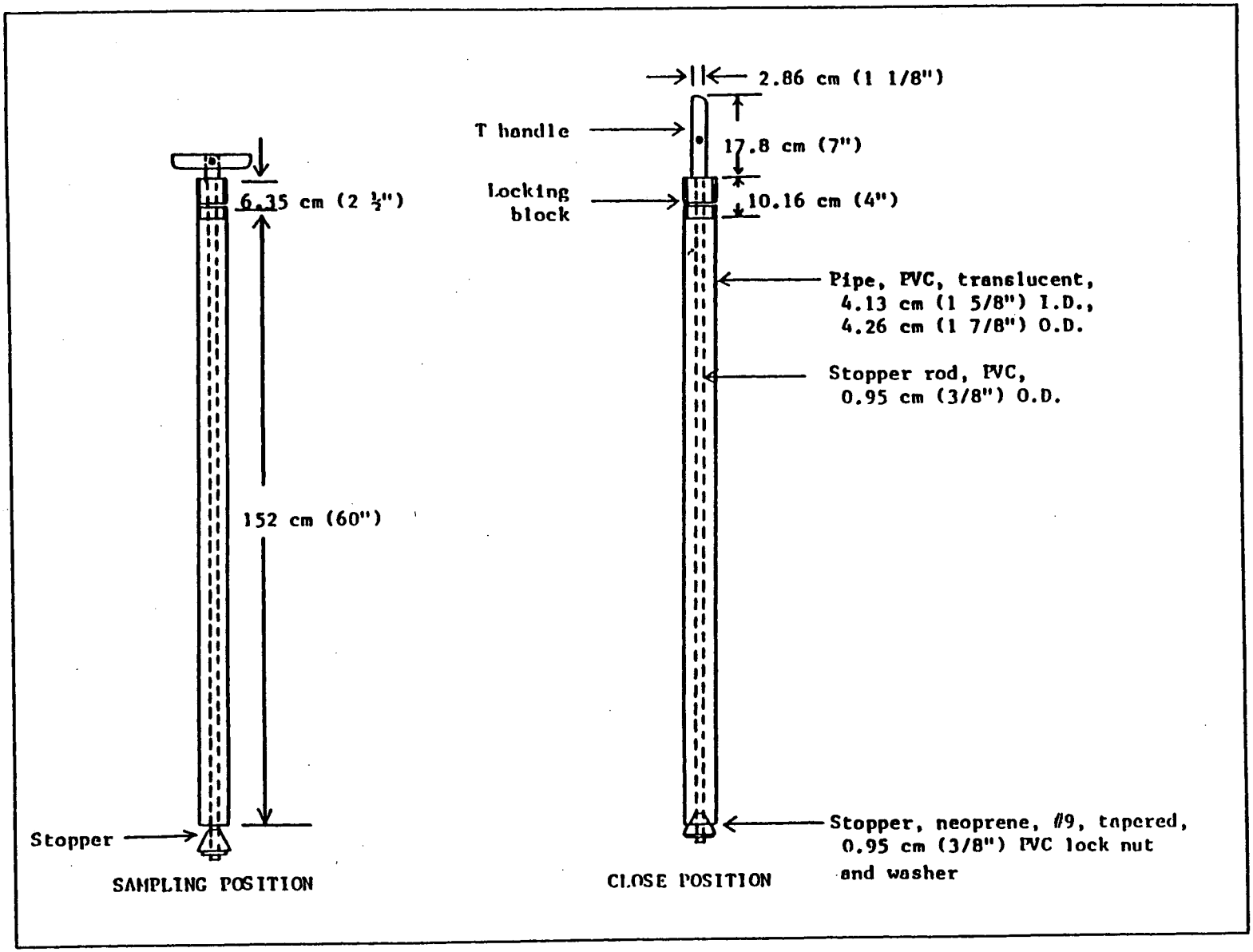


Figure D-2. Composite liquid waste sampler (COLIWASA)

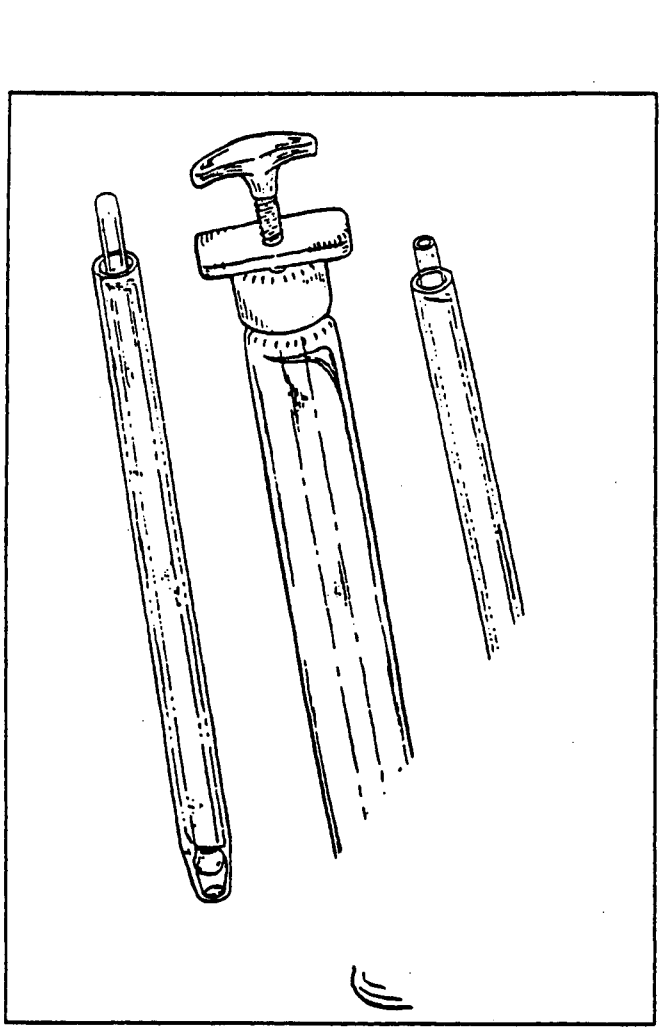


Figure D-3. Glass type composite liquid waste sampler (COLIWASA)

- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Check that a PTFE liner is present in cap. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents, drum log sheets, and/or records in field logbooks (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use an between sampling locations.

(4) Sampling trier.

(a) Applicability. The sampling trier is used t obtain a core sample and is preferred when the samplin media is moist or sticky. It can be used for powdered granular, or soil samples in relatively shallow containers however, powdered or granular materials may provide lo yield.

(b) Method summary and equipment. Solid sample from open containers can be readily collected by pushin the trier into the medium and cutting the desired co sample (Figure D-4).

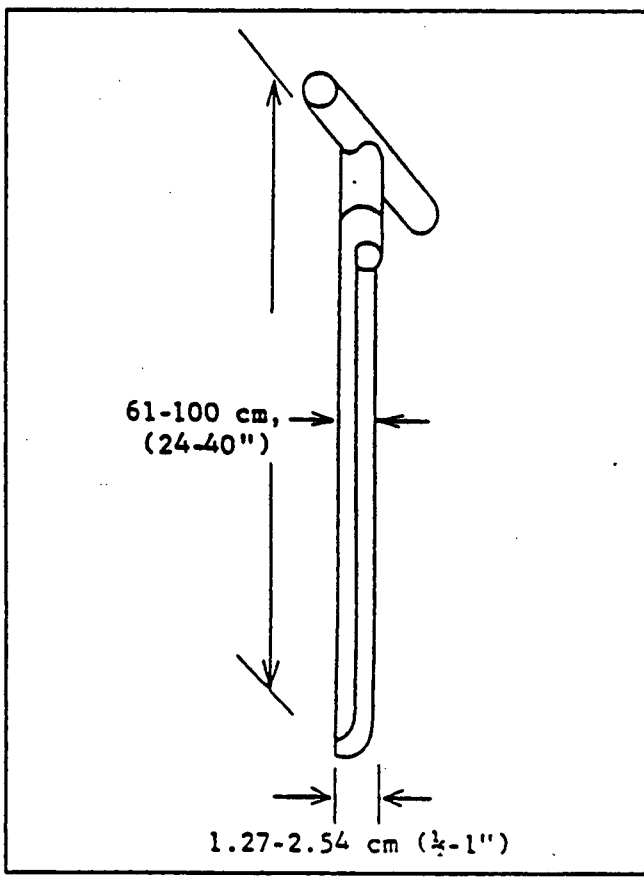


Figure D-4. Sampling trier

(c) Sampling procedure.

- Insert the trier into the waste material at a 0- t 45-deg angle from horizontal. This orientatio

minimizes the spillage of sample from the sampler. Extraction of samples may require tilting of the containers.

- Rotate the trier once or twice to cut a core of material.
- Slowly withdraw the trier, making sure that the slot is facing upward.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters, or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Repeat the sampling at different points two or more times and combine the samples in the same sample container.
- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents, drum log sheets and/or record in field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Packaging and Shipping," in Appendix F.
- Decontaminate sampling equipment after use and between sampling locations.

(5) Grain sampler.

(a) Applicability. The grain sampler is used to sample powdered or granular wastes or materials in bags, fiber drums, sacks, or similar containers. This sampler is most useful when the solids are no greater than 0.6 cm in diameter. It is generally used for non-cohesive materials.

(b) Method summary and equipment. Samples from granular and powdered materials can be easily obtained with a grain sampler (Figure D-5).

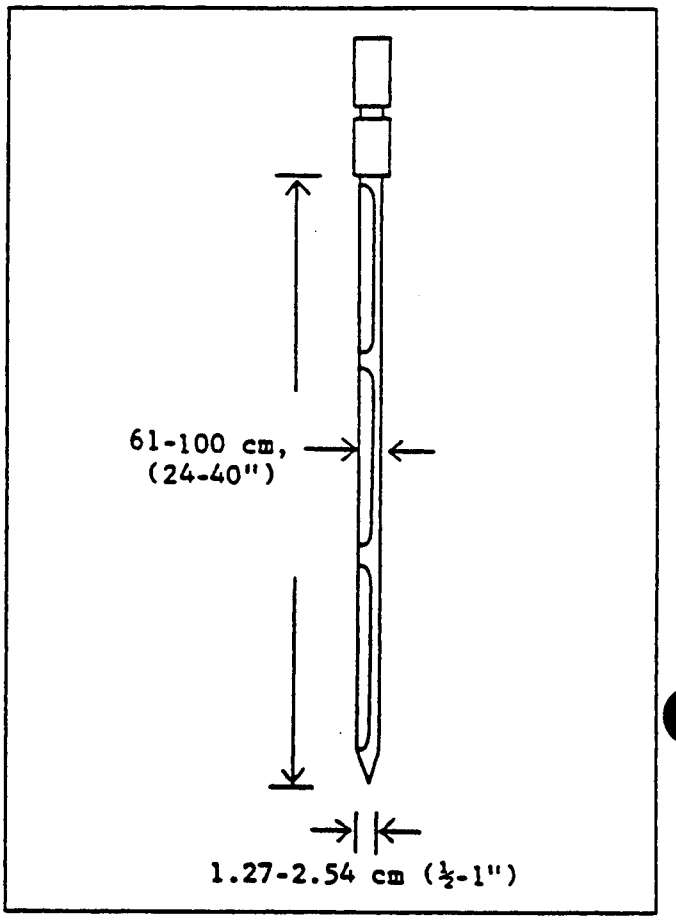


Figure D-5. Grain sampler

(c) Sampling procedure.

- While the sampler is in the closed position, insert it into the granular or powdered material or waste being sampled from a point near a top edge or corner, through the center, and to a point diagonally opposite the point of entry.
- Rotate the inner tube of the sampler into the open position.
- Wiggle the sampler a few times to allow materials to enter the open slots.

- Place the sampler in the closed position and withdraw the sampler from the material being sampled.
- Place the sampler in a horizontal position with the slots facing upward.
- Rotate and slide the outer tube from the inner tube.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Collect two or more core samples at different points and combine the samples in the same container.
- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents, drum log sheets, and/or records in field logbooks (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(6) Waste pile sampler.

(a) Applicability. The waste pile sampler is essentially a large sampling trier and is primarily used for sampling wastes in large heaps with cross-sectional diameters greater than 1 m. Other uses are explained in Section D-1.d(4)(a).

(b) Method summary and equipment. Solid samples from large containers or heaps can be collected by pushing the sampler down into the medium and then retracting the device to obtain a core sample (Figure D-6).

(c) Sampling procedure.

- Insert the sampler into the waste material being sampled at 0 to 45 deg from horizontal.
- Rotate the sampler two or three times in order to cut a core of the material.
- Slowly withdraw the sampler, making sure that the slot is facing upward.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Repeat the sampling at different sampling points two or more times and combine the samples in the same sample container.
- Transfer the sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents and record in field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(7) Veihmeyer sampler.

(a) Applicability. The Veihmeyer sampler is used to sample deeper soils, large heaps, and containers that

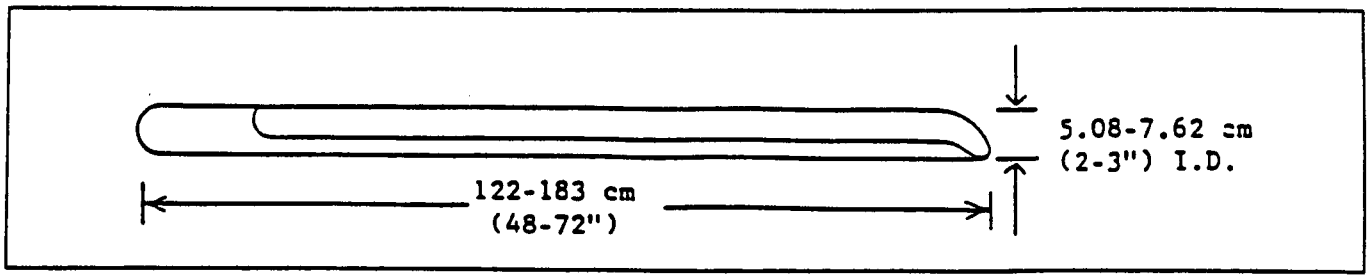


Figure D-6. Waste pile sampler

contain hard substances. It is designed to penetrate specific types of media without pushing the medium ahead of it, thus preventing the core from compacting in the tube.

(b) Method summary and equipment. Core samples from large heaps or hard, crusty materials can easily be obtained with a Veihmeyer sampler (Figure D-7).

(c) Sampling procedure.

- Assemble the sampler by screwing in the tip and the drive head on the sampling tube.
- Insert the tapered handle (drive guide) of the drive hammer through the drive head.
- Place the sampler in a perpendicular position on the soil to be sampled.
- With the left hand holding the tube, drive the sampler into the ground to the desired sampling depth by pounding the drive head with the drive hammer. Do not drive the tube further than the tip of the hammer's drive guide.
- Record the length of the tube that penetrated the ground.
- Remove the drive hammer and fit the keyhole-like opening on the flat side of the hammer onto the drive head. In this position, the hammer serves as a handle for the sampler.
- Rotate the sampler at least two revolutions to shear off the sample at the bottom.
- Lower the sampler handle (hammer) until it just clears the two ear-like protrusions on the drive head and rotate about 90 deg.

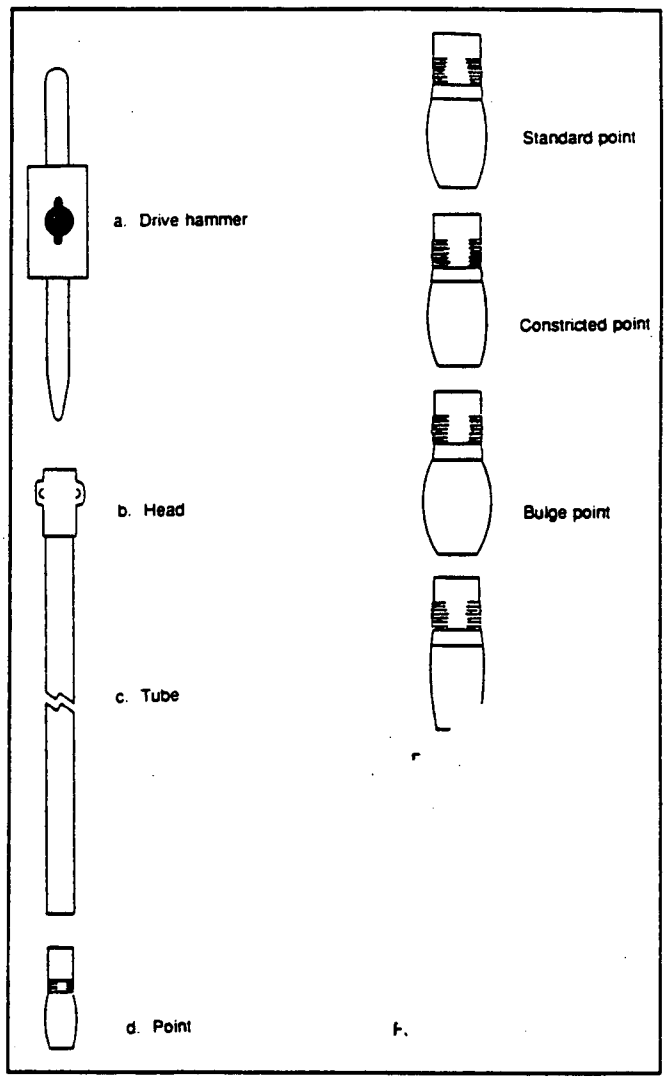


Figure D-7. Veihmeyer sampler

- Withdraw the sampler from the ground by pulling the handle (hammer) upwards. When the sampler

cannot be withdrawn by hand, as in deep soil sampling, use the puller jack and grip.

- Dislodge the hammer from the sampler; turn the sampler tube upside down; tap the head gently against the hammer; and carefully recover the sample from the tube. The sample should slip out easily.

- Store the core sample, preferably in a rigid, transparent, or translucent plastic tube when observation of soil layers is to be made. The use of the tube will keep the sample relatively undisturbed. In other cases, use a 1,000-or 2,000-ml (1-qt. or ½-gal) sample container to store the sample.

- Collect additional core samples at different points.

- Secure the cap tightly.

- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.

- Complete all chain-of-custody documents and record in field logbooks (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Packaging and Shipping," in Appendix F).

- Decontaminate sampling equipment after use and between sampling locations.

e. Decontamination procedures. All sampling equipment must be decontaminated prior to its use. Sampling equipment should be cleaned as described in Instruction E-5 (Appendix E). Sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time.

f. Field control sample requirements. Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks and replicate samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 (Appendix H).

g. Documentation requirements. Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and the time of entry should be recorded. At the end of each day's activity, or entry of a particular event, if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and initial the page indicating the conclusion of the entry or of the day's activity. All aspects of sample collection and handling, as well as visual observations, should be documented in the field logbooks. Documentation should be recorded in prenumbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced. Documentation should include:

(1) Project name.

(2) Container type, size, and markings.

(3) Sample/waste description.

(4) Waste volume assessment.

(5) Date and times.

(6) Sampling personnel present (identify responsibilities, if applicable).

(7) Level of PPE worn.

(8) Weather or any environmental condition which may affect the samples.

(9) Equipment utilized.

(10) Calibration data for field screening instruments.

(11) Deviations to the approved workplans/SAP implemented.

(12) A sketch of the sampled area (denoting original sample container locations to site locations).

(13) Notation of the system for identifying and tracking all samples taken to their associated QC samples.

(14) Notation of any visitors to the site.

(15) Initials and date on each page.

(16) Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks shall be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology that might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sampling form or pre-printed drum log sheets may be used in lieu of a field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should also be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

D-2. Transformer Sampling

a. Scope and application. Instructions presented in this section are for collecting representative samples from transformers. Transformers can be classified into two primary types: pole-mounted, and ground-mounted. Ground-mounted transformers are usually rectangular in shape and are mounted on the ground surface or in some cases below ground. Pole-mounted transformers are usually round or oval in shape and are typically mounted above ground. Instructions for sampling transformers by the following techniques are included in this section: outlet sampling method, glass thieving tube, and composite liquid waste sampler (COLIWASA).

b. Sampling strategies. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme to characterize hazardous waste transformer contents should follow the fundamentals of scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants.

(1) Sampling locations. Sampling transformers is somewhat different than sampling other bulk objects. Transformers are often located in secured, out-of-the way locations, and access may present problems. Transformers may be located in underground cells.

(2) Types of samples. Samples collected from transformers are typically discrete samples. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected immediately and at one particular point in the sample matrix. Representativeness of such samples is defined by the nature of the materials being sampled. Composites are non-discrete samples composed of two or more specific aliquots collected at various sampling locations and/or different points in time. Analysis of this type of sample produces an average value and can, in certain instances, be used as an alternative to analyzing a number of individual grab samples and calculating an average value. The objective of sampling transformers is to identify the potential regulatory status of the equipment and the potential presence of polychlorinated biphenyls (PCBs) in the dielectric fluid contained within the transformer. Therefore, the only appropriate sample type is the discrete sample. Compositing could mask the presence of contaminants by diluting isolated concentrations of the contaminants.

(3) Suggested samplers. Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) Sample frequency. Transformer sampling requires one sample per transformer to assess the potential hazardous nature (PCB content) of the transformer fluid.

c. Sample preservation and handling. Preservation methods and sample containers should be as prescribed in the analytical method or as identified by the analytical laboratory. Since transformer fluids are typically an oil matrix, the preservation method would be cooling. Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedure," in Appendix F. Improper sample handling may alter the analytical results of the sample. Samples should be transferred in the field from the sampling equipment directly into the container that has been specifically prepared for that analysis or set of compatible parameters.

(1) Sample containers. When sampling transformers, glass bottles with PTFE caps should be used. (PTFE is commonly referred to using the registered name of Teflon.) Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned prior to sampling. The cleanliness of a batch of precleaned bottles should be verified by the

container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods are limited to refrigeration and protection from light. The sampler should refer to Appendix I or the specific preservation method.

(3) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(c) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(d) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(e) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(f) Field personnel should use sampling equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned.

d. Sampling methods. Presented below are sampling instructions for the most common techniques for collecting transformer samples. Prior to sample collection, the sampling location and site characteristics (including the condition of the equipment) should be recorded in the field logbook. Selection of sampling equipment is usually based on access to the transformers. If it is possible to obtain access to the contents of the transformer by removing the cover, a COLIWASA or glass thieving tube should be used for sampling. The outlet sampling method should only be used if other sampling methods are not possible. The toxic nature of PCBs and degree of hazard posed by their potential presence in a transformer dictate that a high level of caution should be used. Spill prevention control should be accomplished by using plastic sheeting and sorbent pads. Most importantly, the transformer must be certified as "off-line" and de-energized by an electrician or other responsible person. Once the power source to the transformer is cut and spill control measures (plastic sheeting on the ground and/or the floor surface of the lift) are in place, the cover of the transformer, if accessible, can be removed with hand tools.

(1) Outlet sampling method.

(a) Applicability. Sampling from the transformer outlet valve is probably the easiest method of transformer sampling. However, because the outlet valve is typically located at the base of the transformer, sample stratification may be a problem. PCBs are generally heavier than other insulating oils and may sink to the bottom, preventing the collection of representative samples utilizing the transformer outlet.

(b) Method summary and equipment. A clear, plastic (tygon) tube is placed over the transformer outlet, and the outlet is opened allowing the oil to flow from the tube into a sample jar. It is usually advisable to have a catch bucket below the outlet to capture any spilled oil.

(c) Sampling procedure.

- Install bucket or pan under the electric equipment sampling outlet to catch overflow oil.

- Obtain clear, plastic tubing (tygon). Attach one end of the tube to the electrical equipment sampling outlet valve and place the other end of the tube in the sample container. The tubing between the transformer and the container should be as short as possible to avoid leakage potential. The

tube should be a smaller diameter than the valve ends to ensure that there is no leakage.

- Drain some oil through the sample valve cock and tubing into the overflow bucket or pan to ensure that there are no contaminants present in the sampling line. Then close the sample valve cock.
- After draining some oil through the sampling line, place the tubing in the sample container.
- Open the sample valve cock on the transformer.
- Fill the sample container.
- When the sample container is completely full of oil, close the transformer valve.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents and record them in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare sample for shipment (see Instruction F-2, "Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(2) Glass thieving tube.

(a) Applicability. The glass thieving tube is relatively inexpensive and easy to use, but it requires removing the transformer cover.

(b) Method summary and equipment. The glass thieving tube typically consists of a 6- to 16-mm inside diameter (ID) (1/4 to 5/8-in. ID) 1.2-m (48-in.) long glass tube. To sample, the cover of the transformer is removed, and the glass thieving tube is lowered into the oil.

(c) Sampling procedure.

- Remove the cover from the transformer.
- Insert glass tubing almost to the bottom of the transformer. Approximately 0.3 m (1 ft) of tubing should extend above the drum.
- Allow the oil in the transformer to reach a constant level in the tube during the tube's descent.
- Cap the top of the sampling tube with a tapered stopper or thumb, ensuring that the liquid does not come in contact with the stopper or thumb.
- Carefully remove the capped tube from the transformer and insert the uncapped end into the sample container, being careful not to spill any oil outside the container.
- Release the stopper or thumb and allow the oil to drain into the sample container until it is approximately two-thirds full.
- Remove the tube from the sampler container and dispose of the tube properly.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample tag. Be sure to label the tag carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents and record them in field logbooks (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Packaging and Shipping," in Appendix F).

(3) Composite liquid waste sampler (COLIWASA).

(a) Applicability. The COLIWASA is capable of obtaining a representative sample of multiphase containerized liquids. In comparison with the other transformer sampling methods, it is more expensive and decontamination is more difficult.

(b) Method summary and equipment. The COLIWASA is designed to permit collection of representative samples from multiphase containerized liquids. COLIWASAs are commercially available and typically consist of a 1.5-m (5-ft) by 40-mm (1-1/2-in.) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

(c) Sampling procedure.

- Choose the plastic (Figure D-2) or glass ball type stopper (Figure D-3) COLIWASA for the liquid waste to be sampled and assemble the sampler.

- Ensure that the sampler is functioning properly. Adjust the locking mechanism if necessary to make sure the stopper provides a tight closure.

- Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block. The open position for the glass ball type is achieved by pulling up on the inner rod, thereby pulling the glass ball away from the tapered end of the outer tube.

- Slowly lower the sampler into the liquid waste. (Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sampler tube is lower than the level outside of the sampler, the sampling rate is too fast and will result in a nonrepresentative sample).

- When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block. The closed position for the glass ball type is achieved by pushing the glass ball end of the inner rod against the tapered end of the outer tube.

- Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.

- Carefully discharge the sample into a suitable sample container by slowly opening the sampler. This is done by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container. Repeat as necessary.

- Secure the cap tightly.

- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.

- Complete all chain-of-custody documents and record them in the field logbook (see Instruction F-1, "Documentation," in Appendix F).

Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).

- Decontaminate the sampling equipment after use and between sampling locations. Since the tube is small and difficult to decontaminate, it may be cost-effective to dispose of the sampler and to use new ones for additional sampling.

e. Decontamination procedures. All equipment must be decontaminated prior to its use. The inside surface of tubing apparatus must be decontaminated by drawing the decontamination solution through the equipment. Sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time. Sampling equipment should be cleaned as described in Instruction E-5 (Appendix E).

f. Field control sample requirements. Field control samples are collected by the sampling team to determine whether data are of suitable quality. They include blanks and replicates. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 (Appendix H).

g. Documentation requirements. Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and the time of entry recorded. At the end of each day's activity, or entry of a particular event, if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and initial the page indicating the conclusion of the entry or of the day's activity. All aspects of sample collection and handling, as well as visual observations, shall be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced. Documentation should include:

(1) Project name.

(2) Transformer type and markings.

(3) Date and times.

(4) Sampling personnel present (identify responsibilities, if applicable).

(5) Level of PPE worn.

(6) Weather or any environmental condition that may affect the samples.

(7) Equipment utilized.

(8) Calibration data for field screening instruments, if used.

(9) Deviations from the approved workplans/SAP implemented.

(10) Notation of the system for identifying and tracking all samples taken to their associated QC samples.

(11) Notation of any visitors to the site.

(12) Initials and date on each page.

(13) Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks shall be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology that might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. Sampling forms containing the previously described information can be developed and used in lieu of a field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initiating the sampling program.

Appendix E
Sample Manipulation Instructions

E-1. Filtration Techniques (Liquid Media)

a. Scope and application. This section outlines two different techniques for the filtration of liquid media (i.e., groundwater, surface water, and potable water). The procedures will address in-line filtration, where the filter assembly is under positive pressure, and vacuum filtration, where the filter assembly is under negative pressure. In addition, the procedures describe and recommend specific filtration equipment. Filtration of aqueous samples is performed when the removal of silt, algae, particulates, and other debris is desired. Predominantly, filtration is employed when water samples are to be tested for dissolved metals. Filtered samples for metals (dissolved fraction) should be analyzed in conjunction with non-filtered samples to determine the metal concentration in solution versus metals associated with solids. Analysis of both filtered and unfiltered samples will allow the determination of metal concentration associated with the solid. Filtration should not be conducted in conjunction with organics analysis.

b. Filtration techniques. The following instructions will focus on positive and negative pressure filtration of aqueous media. In the instructions, specific types of filtration devices will be referenced. Because most filtration will be for the purpose of determining "dissolved" versus total metals, these instructions assume a filter pore size of 0.45 µm. Analytical methods used to determine dissolved metal concentrations have historically used 0.45-µm filters to separate dissolved and particulate phases. Filters less than 0.45 µm may be necessary in certain circumstances.

(1) Positive pressure filtration. Aqueous samples that may require positive pressure filtration include groundwater samples, surface water samples, and potable water supply samples. To filter an aqueous sample using the positive pressure technique, a pump, filter, and tubing are required. The following are examples of equipment that may be used for positive pressure in-line filtration.

(a) Pump:
Pump System
High Flow Range: 3 - 2,300 mL/min
Low Flow Range: 06 - 460 mL/min
System Flow Control: ± 10%

(b) Filter assembly:
Groundwater Sampling Capsule
0.45-µm pore size
1/4" - 1/2" tapered barb fitting
Continuous Use Pressure: 60 psi @ Ambient
Maximum Momentary
Pressure: 100 psi @ Ambient

(c) Filtration procedure.

- Use polytetraflouroethylene (PTFE), (PTFE is commonly referred to using the registered name of Teflon) tubing for pump and filter connections.
- Connect the 0.45-µm in-line filter to the discharge tubing from the pump. Make sure the flow arrow on the filter is pointing in the correct direction.
- Apply pressure to the liquid sample (via pump) to force it through the filter into a sample container.
- Replace the in-line filter when the flow becomes too restricted because of buildup on the filter. To replace the filter:
  - Discontinue pumping (turn off pump).
  - Relieve the pressure in the system (line between the pump and the filter).
  - Disconnect the filter and replace with a new one.

(2) Negative pressure filtration. Aqueous samples which may require negative pressure filtration include groundwater samples, surface water samples, and potable water supply samples. To filter an aqueous sample using the negative pressure technique, a pump, filter, sample collection container, and tubing are required. The following equipment may be used for negative pressure (vacuum) filtration:

(a) Pump:
Hand-Operated Vacuum/Pressure Pump
Maximum Vacuum: 25-in. Hg
Maximum Pressure: 15 psi
Composition: Metal or PVC

(b) Filter Assembly:
Nalgene Filter Funnel/Collection Flask
Filter Composition: Cellulose nitrate

Pore Size:	0.45 or 0.8 µm
Collection Flask Capacity:	500 mL
Composition of Assembly:	Polystyrene (sterilized)

(c) Filtration procedure.

- Select a presterilized filter assembly with a 0.45-µm pore size.
- Connect vacuum tubing to the pump and the filter assembly. Use PTFE tubing for pump and filter connections.
- Pour the aqueous sample into the filter funnel portion of the filtration assembly. Avoid transferring solids that may have settled to the bottom of the collection flask.
- Using the hand pump, create a vacuum in the collection flask portion of the filtration assembly to start filtration.
- Replace the filter funnel portion of the assembly when the filter becomes too restricted because of solids buildup on the filter. To replace the filter:
  - Depress the pressure/vacuum release button.
  - Disconnect the filter funnel and replace it with a new one.
  - Create a vacuum with the hand pump and continue filtering the remaining sample.

c. Potential problems. One inherent problem associated with the filtration of aqueous environmental samples is the filter becoming clogged. The following are some considerations regarding liquid filtration.

(1) Always have extra filters available at the sampling site.

(2) Prefilter dirty samples with a larger pore size filter.

(3) For highly turbid samples a negative filtration system may be more efficient.

(4) Avoid pouring sediments from the bottom of the collection flask into the filter funnel.

(5) When the filtrate flow becomes too slow because of filter loading, change the filter. Avoid increasing the pressure and rupturing the filter membrane.

E-2. Homogenizing Techniques

a. Scope and application. The purpose of this section is to provide instructions for homogenizing samples. Proper homogenization is vital to accurately assessing the condition of a particular site. Correct homogenization techniques are also important for preparing the necessary quality control samples associated with a typical sampling event. Homogenization techniques should not be used when samples for volatile organic analyses or other parameters that require undisturbed samples are collected.

b. Sample handling and mixing. An integral part of any sampling investigation is obtaining samples that truly represent the site under investigation. Therefore, applying proper homogenization techniques will help ensure that conditions are being accurately represented. Another assessment that is being made at most sites is field and lab quality control. Generation of field control samples provides a means for evaluating a laboratory's performance and the sampling and handling techniques of field personnel. However, for this evaluation to be meaningful, field sampling personnel must be able to properly homogenize and divide collected samples.

(1) Sampling equipment composition. The composition of sampling equipment can affect sample analytical results. Sampling materials used must not contaminate the sample being collected and the sampling equipment must be decontaminated between samples to prevent the samples from being cross-contaminated. The standard materials for sampling equipment used to collect samples for trace organic compounds or metals analyses are, in order of decreasing desirability: glass, stainless steel, and PTFE. The following table may be used as a guide to select the proper sampling instruments.

(2) Required sample volumes. The volume of sample obtained should be sufficient to perform all required analyses with an additional amount collected to provide for quality control needs, split samples, or repeat examinations. Appendix G discusses typical sample volume requirements for various parameters. The volume of sample required by the laboratory depends on the analyses to be performed. The laboratory receiving the sample should be consulted for any specific volume requirements.

The volumes of samples collected from waste sources at hazardous waste sites or samples from sources that are known to be toxic should be kept to an absolute minimum since disposal costs of excess sample material are high. The laboratory or project personnel may require that excess sample volume be returned to the site because of the hazardous nature of the samples or because of sensitive political issues surrounding the project. If samples are being collected for bench scale or pilot scale remediation studies, larger volumes may be necessary. This scenario normally involves sending large bulk volumes to a laboratory to undergo various applications/manipulations to identify the optimum conditions for remediation of a particular waste stream. The ultimate data user (design engineer) or laboratory should be contacted to determine the volume of material required.

Analysis/Site Condition	Preferred Material
Metals	Glass or PTFE
Organics	Stainless steel, glass, or PTFE
Corrosive Soil/Waste	Glass or PTFE

(3) Aqueous samples. Aqueous samples are typically homogenous because of the physical properties of water, such as diffusion and the ability to flow and freely mix. Therefore, aqueous samples do not require mixing. However, viscous or semi-solid liquids will require mixing. These samples can be shaken well to mix or stirred thoroughly with a tool of appropriate composition. The sampler may encounter contaminants that are not miscible with water and will separate into distinct phases. In these situations, it is advisable to collect a sample from each layer/phase as well as a homogenized sample. When multiple phases are sampled, the sample should be homogenized in the laboratory to achieve the most homogenous sample. Water samples (potable well, monitoring well, surface water) should be obtained by alternately filling sample containers from the same sampling device for each parameter. Split and duplicate samples will be collected simultaneously with the primary samples. Containers for volatile organic analyses (VOA) will be filled first, followed by containers for semivolatile organics, metals, cyanide, and water quality parameters. Each VOA container should be completely filled immediately, rather than splitting the water between bottles and filling the bottles incrementally. The containers will all be filled from the sampling device if possible. If this is not possible, a minimum of two containers (one for the primary sample and one for the split sample) will be filled from each sampling volume. If more than two containers can be filled from one sampling volume, the number of containers filled must be an even number (i.e., 2 or 4) so that an equal number of containers for the primary and split samples are prepared. The remaining portions of the sample will then be prepared by splitting each sampling volume between containers for the primary and split samples.

(4) Solid samples. Obtaining samples in a soil or sediment matrix requires homogenization of the sample aliquot prior to filling sample containers. However, volatile organic samples are the exception; samples being analyzed for volatile organic compounds (VOCs) must always be taken from discrete locations prior to mixing. This practice is necessary to prevent loss of volatile constituents and to preserve, to the extent practicable, the physical integrity of the volatile fraction. Homogenization of the sample for remaining parameters is necessary to create a representative sample volume. Moisture content, sediments, and waste materials may inhibit the ability to achieve complete mixing prior to filling sample containers. Therefore, it is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample location. Homogenization should be accomplished by filling a properly decontaminated stainless steel tray or bowl with the sample and mixing it with a decontaminated stainless steel or PTFE instrument. The method of choice for mixing is referred to as quartering and can be performed in a bowl or tray of an appropriate material (material depends on the parameters to be analyzed for). The soil in the sample pan is divided into quarters. Each quarter is mixed, then all quarters are mixed into the center of the pan. This procedure is followed several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion and occasionally turning the material over. The extent of mixing required will depend on the nature of the sample and should be done to achieve a consistent physical appearance prior to filling sample containers. Once mixing is completed, the sample should be divided in half and containers should be filled by scooping sample material alternately from each half.

c. Potential problems.

(1) The higher the moisture content, the more difficult it is to homogenize the sample.

(2) A true homogenization of soil, sediment, or sludge samples is almost impossible to accomplish under field conditions.

(3) VOC samples are not homogenized due to the possible volatilization of constituents.

E-3. Compositing Samples

a. Scope and application. This instruction provides information on the various types of composite sampling techniques and the proper procedures to obtain a composite sample. The technique of compositing discrete samples is typically employed when the site under investigation is quite large. Composite sampling is not specific to one matrix, rather it can be utilized for solid, semi-solid, and liquid matrices.

b. Compositing techniques. There are two principal methods of sampling: grab samples and composite samples. Each method has its own applications, strengths, and weaknesses. Composite samples consist of a series of discrete grab samples that are mixed together to characterize the average composition of a given material. The discrete samples used to make up a composite sample are of equal volume and are collected in an identical fashion. Likewise, the number of grab samples forming a composite should remain consistent (i.e., a number and pattern for collection of grab samples within a grid should be selected and, for a given grid size, should not be changed). Four types of composite samples are discussed below.

(1) Flow-proportioned composite: Flow-proportional composite samples are collected proportional to the flow rate during the compositing period by either a time-varying/constant volume or a time-constant/varying volume method. Flow-proportioned composite samples are typically collected using automatic samplers that are paced by a flow meter. This type of sampling is usually associated with wastewater sampling. Figure E-1, a and c, illustrates flow-proportioned composite sampling.

(2) Time composite: A time composite sample is composed of a varying number of discrete samples collected at equal time intervals during the compositing period. The time composite sample is typically used to sample wastewater or streams. Time composite samples are typically obtained using automated programmable samplers. When a large number of locations must be sampled, automatic samplers may be set up to sample these locations simultaneously with a minimum of supervision and costs. When sampling activities are relatively complex, as in the case of composite sampling proportional to flow, automatic samplers reduce human error. Automatic samplers can directly correlate flow with both sample size and time. In hazardous situations, use of automatic samplers can reduce personnel contact with hazardous waste streams or with potentially dangerous sampling environments. The disadvantages of automatic sampling equipment are its high cost and extensive maintenance requirements. These disadvantages can be offset by reduced labor requirements, proper maintenance, and the proper choice of equipment. When access to the waste stream is relatively easy and sufficient labor is available, manual methods are also quite effective. The most significant disadvantage of manual sampling is that it is labor-intensive, particularly with respect to long-term composite sampling. Figure E-1b illustrates equal time compositing.

(3) Areal composite: Areal composite samples are samples collected from individual grab samples collected on an areal or cross-sectional basis. Areal composites are made up of equal volumes of grab samples where all grabs are collected in an identical manner. Areal composite sampling is typically used for stream sediment equal-width compositing and surface/subsurface soil sampling.

(4) Vertical composite: Vertical composite samples are also collected from individual grab samples but taken from a vertical cross section. Vertical composites are also made up of equal volumes of grab samples where all grab samples are collected in an identical manner. Vertical profiles of soil and sediment columns are an example of vertical compositing.

c. Compositing grab samples. Typically, composite sampling is the technique of choice when the area under investigation is very large and a large number of discrete samples will be generated. Compositing grab samples lends itself to lowering analytical costs because it reduces the number of analyses. Collecting composite samples also requires decisions, including but not limited to, the type of composite sampling technique that will meet the project needs (i.e., time composite, area composite...); the number of composite samples needed; the number of grab samples in each composite; and the type of sampling grid. These issues are not discussed in this instruction but can be found in other USACE guidance documents.

(1) Solid matrix. Composite samples should be prepared as follows:

(a) Collect discrete grab samples using the appropriate instructions as outlined in Instructions C and D. To obtain a representative composite sample, it is important that all grab samples are collected in identical fashion.

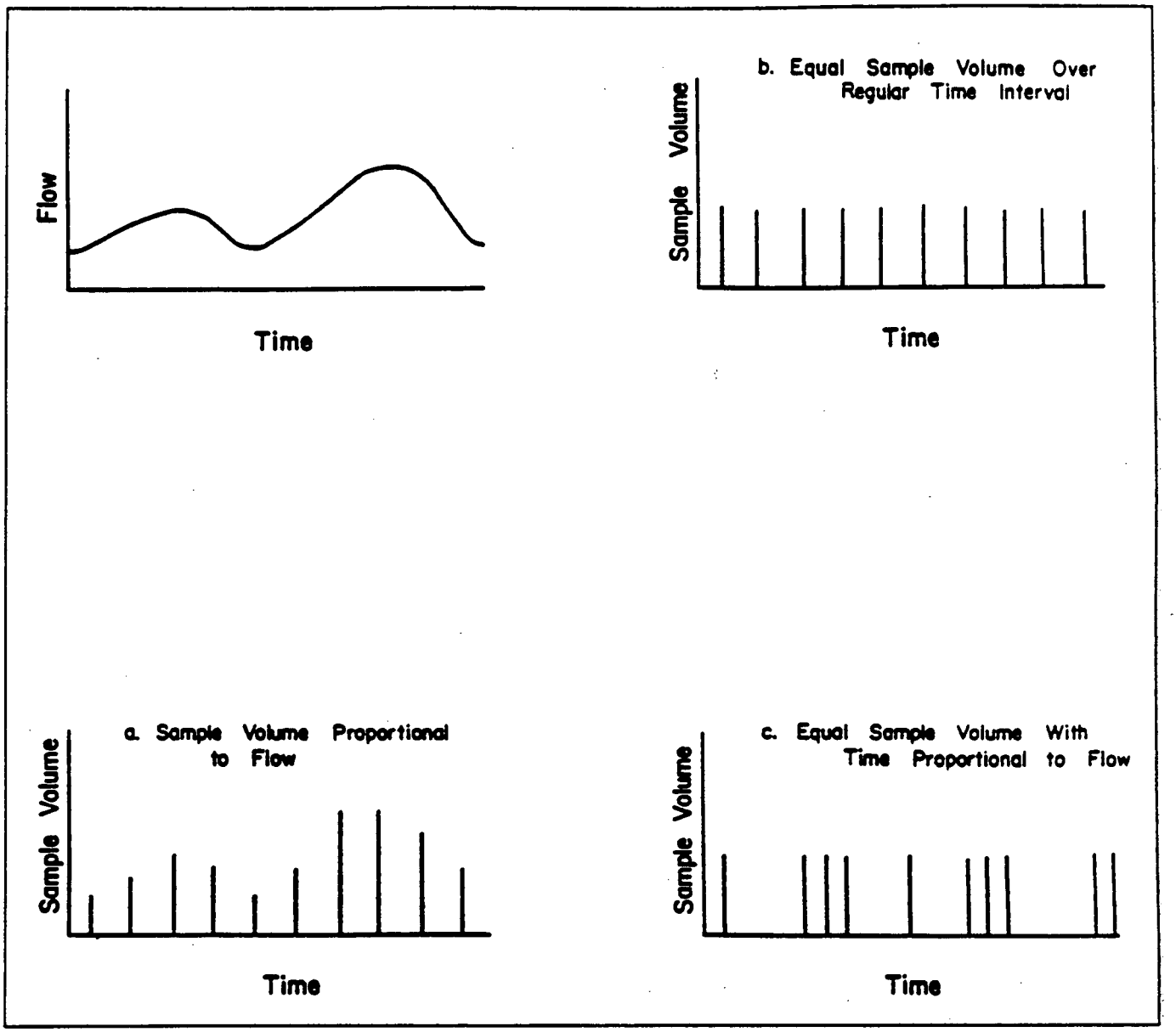


Figure E-1. Composite sampling methods

(b) Homogenize individual grab samples as outlined in Instruction E-2, and place them into proper sample containers.

(c) Assemble the sample containers that contain the grab samples that will make up a specific composite sample.

(d) Remove an aliquot of sample from each sample container and place it into a clean stainless steel mixing bowl. Each aliquot amount is to be as identical as possible to facilitate representativeness. Avoid generating excess contaminated soil when possible.

(e) Homogenize the aliquots as described in Instruction E-2.

(f) Remove sample amounts from the homogenized composite sample and place them into the proper containers for shipment to the laboratory.

(g) At some sites it may be beneficial to save and store the individual homogenized grab samples after aliquots are removed for compositing. If the composite sample results do not appear to be accurate, subsequent analyses of the individual grab samples that comprised the composite may confirm the results. Confirmatory analyses of these samples would likely be for informational purposes only since the holding times of the samples may have expired.

(2) Liquid matrix. The preparation of liquid matrix composite samples is typically easier than solid matrices due to the ease in homogenizing liquids. Also, it is common practice to send liquid grab samples to the laboratory for compositing because of the difficulties in handling larger sample volumes (1 to 4 gal for a typical wastewater sampling event) and the increased potential to introduce contaminants. Good documentation of sampling locations is essential in all field sampling, particularly when several grab samples have been homogenized to form a composite. If a contaminant is detected in a composite sample, each of the discrete grab samples that made up the composite will need to be analyzed individually to determine the actual distribution of the contamination. Procedures should be established by the project manager and the laboratory to ensure that holding times for the discrete grab samples are not exceeded. When composite samples are to be generated in the field, the following procedure should be used.

(a) Assemble all sample containers that contain the grab samples that will make up a specific composite sample.

(b) Shake or stir the individual containers to homogenize.

(c) Using clean, glass pipets, deliver aliquots of the homogenized grab samples directly into a sample container to be sent to the laboratory. (e.g., It will require five 20-mL pipettings from five discrete grab samples to generate a 100-mL composite sample; the standard volume requested for a metals analysis.)

(d) Seal the container and shake well to mix. Avoid stirring samples if possible to lower the potential of introducing contaminants.

(e) At some sites it may be beneficial to save and store the individual homogenized grab samples after aliquots are removed for compositing. If the composite sample results do not appear to be accurate, subsequent analyses of the individual grab samples that comprised the composite may confirm the results. Confirmatory analyses of these samples would likely be for informational purposes only since the holding times of the samples may have expired.

d. Potential problems.

(1) Compositing does not allow the spatial variability of contamination to be determined. Additional analyses of the individual grab samples is required.

(2) Low concentrations of contaminants in individual grab samples may be diluted so that the total composite concentration is below the detection limit. In this case, the existence of the contamination in individual samples would go unnoticed.

(3) It may be very difficult to create a homogeneous sample mixture if the grab samples are moist and clayey. Consequently, the resulting composite may not represent an average of all the grabs.

(4) Obtaining samples by an automatic sampling device is typically difficult for the first time user. However, after the sampler has become familiar with the sampling device and any problems have been addressed, these devices prove to be quite reliable.

E-4. Laboratory Sub-sampling

a. Scope and application. This instruction provides direction on how to obtain an aliquot of sample for an actual laboratory analysis. Obtaining this aliquot is referred to as laboratory sub-sampling and is performed by laboratory personnel. This instruction addresses sub-sampling techniques for both solid and liquid matrices. Good analytical techniques are required in all sub-sampling to obtain representative sub-sample aliquots and to accurately assess any contamination at the site.

b. Sub-sampling. It is common for most analytical methods to require only a portion of the submitted sample to perform the analysis. Additional sample volume is desirable when there is a potential that the sample will be re-analyzed. Because only a portion of the submitted sample is actually involved in the evaluation of the sampling location, it is important that the sub-sample be truly representative of the entire sample. Environmental samples should be homogenized prior to arrival at the laboratory. However, laboratory personnel should not assume that each sample is properly homogenized in the field. In addition, both solid and liquid matrices may experience settling or phase separation during transport. Therefore, it

is critical that submitted samples be visually inspected for homogenization prior to sub-sampling. Laboratory personnel should document the physical appearance of samples upon receipt, including comments about settling and phase separation. Techniques used to homogenize or re-homogenize samples should also be documented. The approaches to sub-sampling techniques are distinguished by the analytical requirements for the state or condition of the aliquot to be tested. There are two main approaches to sub-sampling that are dependent upon the need for undisturbed versus disturbed samples. For example, although homogenization is critical prior to sub-sampling for suspended solids analyses, homogenization prior to sub-sampling may also release volatile constituents resulting in inaccurate organic analyses. The first approach is relevant for samples that are analyzed for volatile organics or other constituents that require an undisturbed sample. Disturbing these types of samples via mixing, blending, homogenizing, shaking, or stirring may alter the physical/chemical state of the sample and cause a release or alteration of the contaminant of concern and a misleading final analytical result. The second approach is relevant to other analyses that require thorough homogenization prior to sub-sampling. Without some type of mixing, blending, homogenizing, shaking, or stirring operation for these samples, the final analytical results would be questionable.

(1) Procedure.

(a) Solid matrix. Solid matrix samples are to be sub-sampled as follows:

- Allow the sample and container to equilibrate to room temperature before opening the container.

- Visually inspect and document the appearance of the sample prior to sub-sampling. If the subsequent analysis requires an undisturbed sample, no homogenization is performed and the materials are ready for sub-sampling. If the subsequent analysis does not require an undisturbed sample, the entire sample contents should be removed and the sample homogenized regardless of visual observation. Sieving, if necessary, should be conducted after homogenization. To prepare the sub-sample, the sample should be subdivided (quartered) and approximately equal portions removed from each quarter of the sample for inclusion into a final sample aliquot that will undergo analysis.

- For samples that are analyzed for volatile organics or other constituents that require an undisturbed sample, a clean hand core sampler, or similar sampling device, should be used to remove a vertical core segment/aliquot of material from the sample.

- For samples that are analyzed for volatile organics or other constituents that require an undisturbed sample, the sample should be removed from the coring device into a clean, glass beaker or similar container from which a portion can be accurately weighed and analyzed.

- For other sample analyses that require homogenization prior to sub-sampling, the entire aliquot generated from subdivisions in the second step should be accurately weighed in a clean glass beaker or similar container and analyzed. Alternatively, if only a portion of the composited aliquot generated in the second step will be used for subsequent analysis, the subdivisions should be sampled equally into a clean glass beaker or similar container from which a portion can be accurately weighed and analyzed.

(b) Liquid matrix. Liquid matrix samples are to be sub-sampled as follows:

- Allow the sample and container to equilibrate to room temperature. If volatile organic analyses are not required, the container may be opened following temperature equilibration.

- Visually inspect and document the appearance of the sample for homogeneity. This may not be possible due to the container material (i.e., amber glass). If, upon inspection, it is discovered that the sample has more than one liquid phase, consult with the client to determine sampling needs.

- If no phase separation exists, homogenize the sample by shaking well to mix. If the liquid is very viscous, the sample may require stirring (i.e., glass or PTFE stirring rod).

- Depending on the analytical method to be employed, sub-sampling should follow the following approach if the entire sample is to be used (e.g., pesticides, polychlorianted biphenyls (PCBs), semivolatile organics, polycyclic aromatic hydrocarbons (PAHs), etc.). In the preferred method for transferring the entire sample contents, the analyst first marks the water level on the sample container, and then, after shaking, pours the entire contents of the container into the extraction

apparatus. Solvent rinsates from the sample container are also added to the extraction apparatus. Tap water is subsequently poured into the sample container to measure the initial sample volume. If only a portion of the sample is needed, the required sub-sample should be measured using a clean pipet, syringe, or comparable measuring device. Samples should not be collected directly from the sample container except for volatile organic analysis. Sub-samples for volatile organics analysis should be obtained directly from the sample container by piercing the septa of the container using a clean syringe.

c. Potential problems. Sub-sampling the lower phases of a multi-phase liquid may pose special problems. A pipet or syringe needle passing through the lighter layers may pick up contaminants that can bias analytical results. The pipet tip or syringe needle should be wiped clean before transferring lower phase sub-sample to a preparation flask. Removal of the lighter layer(s) prior to sub-sampling may be required to obtain a representative aliquot. Clay soil samples may be difficult to sub-sample with a coring type device. Some hand coring samplers are equipped with clear plastic liner tubes that make extracting the sub-sample from the corer much easier. However, the goal is to obtain a representative sample. In these situations, professional judgement is required and a clean stainless steel spatula may be the tool of choice.

E-5. Decontamination Procedures/Sample Contaminant Sources

a. Scope and application. The purpose of this section is to provide instruction on deciding an appropriate decontamination scheme(s) for the project field sampling equipment in order to prevent or reduce cross-contamination of project samples. The applicability of each step in a decontamination protocol will depend upon the contaminants present onsite, the subsequent analysis to be performed, the composition of the sampling devices, etc. The appropriateness of a decontamination protocol is vital to the eventual validity of the analytical results and decisions made based upon those results. All sampling equipment that has come in contact with a potentially contaminated media must be cleaned prior to the subsequent use of that device. Devices may include bailers, pumps, shovels, scoops, split spoons, tube samplers, augers, etc. Another approach to minimizing the potential for cross-contamination may be to dedicate or use disposable sampling equipment.

b. Decontamination procedures. Refer to the following table for various step-wise decontamination protocols.

(1) Reagents. The detergent wash is a non-phosphate detergent solution used with brushing or circulating techniques to remove gross contamination, and/or as a mild neutralizing agent. Tap water is considered a rinse water, preferably from a water system of known chemical composition. Acid rinses are used as the inorganic solubilizing agent, or as a mild neutralizing agent. These rinses are a 10-percent to 1-percent HCl or HNO_3 solution prepared from reagent grade acids and deionized water, respectively. Solvent rinses are used as an organic solubilizing agent. Requirements for solvent types vary depending upon the nature of known organic contamination requiring solubilization; and any impurities present within the rinse which may potentially interfere or contribute to the subsequent analysis. All solvent rinses used must be of pesticide grade quality. Finally, the deionized water is organic-free reagent water.

(2) Procedure clarifications/exceptions. Refer to Table E-1 for the general necessary procedures based upon site contaminants and/or subsequent analytical protocols. As noted above, the detergent wash is used in conjunction with scrubbing for gross contamination removal, followed by the appropriate rinses. For cleaning of pumping equipment or devices with inaccessible internal mechanisms, suggest circulating/flushing the system with the applicable solutions in the order given below. Solvent rinses for pumping equipment should be limited to a 10-percent dilution (vol./vol.) of acetone or isopropyl alcohol in water. Tubing used with peristaltic pumps may be flushed with hexane or dilute HCl, followed by a distilled water rinse depending on contaminants noted onsite. The decontamination of low carbon steel sampling devices should limit the acid rinse to a dilute 1-percent acid solution. All sampling equipment should be allowed to dry prior to the next use. For this reason it is important to have sufficient sampling devices onsite which may be alternated. This practice will allow a thorough drying of equipment without increasing sampling downtime. Alternatively, larger equipment (e.g., drill rig components, power augers, etc.) may be cleaned with a portable power washer or a steam cleaning machine in lieu of the protocols outlined below. Finally, depending upon the project, it may be appropriate to contain spent decontamination fluids and arrange for eventual disposal as investigation-derived wastes (IDW). Refer to U.S. Army Corps of Engineers guidance on IDW for further information on this subject. In these cases, it is important that these

Table E-1
Procedure Clarifications/Exceptions

	Detergent Wash	Tap Water	Acid Rinse	Tap Water	Solvent Rinse[1]	Deionize Water	Air Dry
VOA Low MW CMPDS[2]	✓	✓			Methanol	✓	✓
BNA PEST/ PCBS High MW CMPDS[2]	✓	✓			Hexane	✓	✓
Organic Bases[3]	✓	✓	(dil.acid) 1% Sol.	✓	Iso-propyl Alcohol	✓	✓
Organic Acids[4]	(dil.base) ✓	✓			Iso-propyl Alcohol	✓	✓
Trace Metals	✓	✓	10% Sol.	✓		✓	✓
Salts	✓	✓				✓	✓
Acidic CMPDS	(dil.base) ✓	✓				✓	✓
Basic CMPDS caustic	✓	✓	(dil.acid) 1% Sol.	✓		✓	✓

[1] Solvent rinses vary in polarity which leads to varying solubilizing properties. Deciding appropriate solvent rinses should first identify if a known or suspect contaminant requires removal from sampling equipment. Optimum solvents for contaminants are noted above. Secondly, it should be identified whether the subsequent analytical protocol would be impacted by an impurity of, or the solvent being used (e.g., residual acetone present in isopropyl alcohol would be measured with certain volatile organics analysis).
[2] MW CMPDS = molecular weight compounds
[3] Organic bases include Amines, Hydrazines.
[4] Organic acids include Phenols, Thiols, Nitro and Sulfonic compounds.

containers be suitable for the eventual disposition of the materials, and therefore comply with any potentially applicable U.S. Department of Transportation regulations.

c. Sample contaminant sources and other potential problems.

(1) Carryover and leaching. Contaminant carryover between samples, and/or from leaching of the sampling devices, is very complex and requires special attention. Decisions concerning the appropriateness of the device's material composition must account for these carryover or leaching potentials, and whether these contaminants are of concern on the project. Materials potentially encountered on projects and their associated common contaminants are listed in Table E-2.

Equipment blanks may be used to assess contamination of this nature, and are discussed in detail in Instruction H-2 in Appendix H.

(2) Adsorption. Contaminant adsorption is another problem which must be considered when deciding on an applicable sampling device or the appropriate composition material. This phenomenon is more critical when sampling an aqueous or gaseous media, due to the capability of lower levels of contaminant detection and the fact that the fluid matrix is more apt to potential contaminant

Table E-2
Materials Potentially Encountered on Projects

Material	Commonly Related Contaminants
Glass	Silicon Boron
Rigid polyvinyl chloride (PVC) (threaded joints)	Chloroform Vinyl chloride
Rigid PVC (cemented joints)	Methyl ethyl ketone Toluene Acetone Methylene chloride Benzene Tetrahydrofuran Ethyl acetate Cyclohexanone Vinyl chloride
PVC plastic tubing	Phthalate esters Vinyl chloride Low level (zinc, iron, antimony, and copper)
Soldered pipes	Lead Tin
Stainless steel	Chromium Iron Nickel Molybdenum
Brass	Copper Zinc Tin

transfer. PVC and other plastics are known to sorb organics and to leach plasticizers and phthalate esters. Polypropylene, and other thermoplastics, have been shown to sorb organics and environmental mercury efficiently, and should therefore be avoided in sampling devices, especially tubing. For these reasons, PTFE is commonly chosen over the PVC and plastics when working with organic or mercury contaminants. In addition, some pesticides and halogenated compounds preferentially adsorb to glass surfaces. For this reason, it is recommended that when taking aqueous samples, the sample container NOT be rinsed prior to sample collection; and the same container be rinsed with the extraction solvent after the sample has been quantitatively transferred to an extraction apparatus. Inorganics (metals) adsorption to containers is dependant upon the specific metal element, the concentration, pH, contact time, complexing agents present, and container composition. This is believed to be nominal and proper preservation of samples should prevent this. In deciding appropriate tubing to be used for aqueous sample acquisition, it is important to decide applicable material composition and diameter based upon the contaminant and the purpose of the data. Adsorption is less likely to occur when there is an increase in tubing diameter.

Appendix F
Sample Documentation and Shipment Instructions

F-1. Documentation

a. Scope and application. This section describes procedures for maintaining sample control through proper sample documentation. When samples are collected for chemical or physical characteristics analysis, documentation such as chain-of-custody and sample analysis request forms, custody seals, and logbooks needs to be completed. The information presented in this section enables maintenance of sample integrity from time of collection through transportation and storage. It is this documentation that will verify that the samples were properly handled.

b. Documentation. The following discussion outlines standard practices and procedures to be used when documenting a sampling episode. All project-specific documentation requirements must be presented in the sampling and analysis plan (SAP). This includes identification of procedures required for field documentation, sample labeling, and the maintenance of chain-of-custody. Applicable requirements are identified in the following paragraphs. In addition, the contractor is required to obtain a tracking number (e.g., Laboratory Information Management System (LIMS) number) from the U.S. Army Corps of Engineers (USACE) technical manager that is used in conjunction with the government quality assurance (QA) sample shipments. The tracking number should be specified in the SAP. Proper completion of the logbook and supporting paperwork with indelible ink is necessary to support potential enforcement actions that may result from the sample analysis. Therefore, maintaining sample integrity through proper documentation is essential.

(1) Field logbooks. Project field logbooks must be bound and should have numbered, water-resistant pages. All pertinent information regarding the site and sampling procedures must be documented in indelible ink. Notations should be made in logbook fashion, noting the time and date of all entries. Information recorded in this logbook should include, but not be limited to, the following:

(a) Name and exact location of site of investigation or interest.

(b) Date and time of arrival and departure.

(c) Affiliation of persons contacted.

(d) Name of person keeping log.

(e) Names of all persons on site.

(f) Purpose of visit.

(g) All available information on site (processes or products, waste generation, nature of spilled material) and the composition and concentration of substance, if known.

(h) Field instrument equipment used and purpose of use (i.e., health & safety screening, sample selection for laboratory analysis), calibration methods used, field results, and quality control (QC) information.

(i) Location of sampling points (including justification) [Note: It is recommended that a sketch of the general surroundings of the sampling area (site) be provided. Sample identification numbers should correspond directly with sample locations].

(j) Identification number, volume, sampling method, and containers (size/type) for each sample collected. Any sample manipulations such as filtration, compositing, and executed preservation techniques should also be documented.

(k) Date and time of sample and data collection and any factors that may affect their quality.

(l) Name of collector.

(m) All sample identification numbers and a description of samples--especially any related QC samples.

(n) Weather conditions on the day of sampling, and any additional pertinent field observations.

(o) Description of the number of shipping coolers packaged (attach associated chain-of-custody forms) and the shipping method employed (note applicable tracking numbers).

(p) Name and address of all receiving laboratories. For sample shipment to the government QA laboratory, note the associated project LIMS number.

(2) Documenting sampling points. The exact locations of sampling points should be documented for purposes of generating an accurate representation of the site conditions using the data generated to date, defining data gaps, and identifying potential future data needs. This is

accomplished through the use of a monument and compass. A monument should be chosen at each site to act as a stationary reference point from which all sampling points can be measured using a compass and measuring tape. If a building or other stationary structure exists, its corner may act as this reference point. If no monument exists, it will be necessary to create one. A piece of wood, approximately 2 in. by 2 in., should be hammered into the ground to almost ground level, making it difficult to remove and thus assuring its permanence. The stake should then be marked with flagging tape or fluorescent paint. When establishing a sampling point, the following procedure should be used:

(a) Standing at the monument, facing the sampling point, use the compass hairlines to determine the degree of direction.

(b) Ensure that the line of sight runs from the monument, through both hairline needles on the compass, to the sampling point.

(c) When first establishing the sampling point, record the degree and direction reading from the compass in the field logbook, along with the distance measurement from the monument to the sampling point.

(3) Photographic documentation. All sampling points should be documented on film. A film record of a sampling event allows positive identification of the sampling point. In some cases, a photograph of the actual sample collected may be required. Photographs are the most accurate and convenient record of field personnel observations. Photographs taken to document sampling points should include two or more reference points to facilitate relocating the point at a later date. Keeping a record of photographs taken is crucial to their validity as a representation of an existing situation. Photograph documentation is invaluable if the sampling and subsequent analytical data end in litigation, enforcement, or cost recovery actions. In addition to photographs, video coverage of a sampling episode can be equally or even more valuable than photographs because it can be used to prove that samples were taken properly as well as the location at which they were taken. Video coverage can be used as a record of site conditions and can give those who have not been onsite an idea of the circumstances. For each photograph taken, the following items should be noted in the field logbook:

(a) Date.

(b) Time.

(c) Photographer (signature).

(d) Name of site.

(e) General direction faced and description of the subject taken.

(f) Sequential number of the photograph and the roll number.

(g) Site photo map (see Figure F-1).

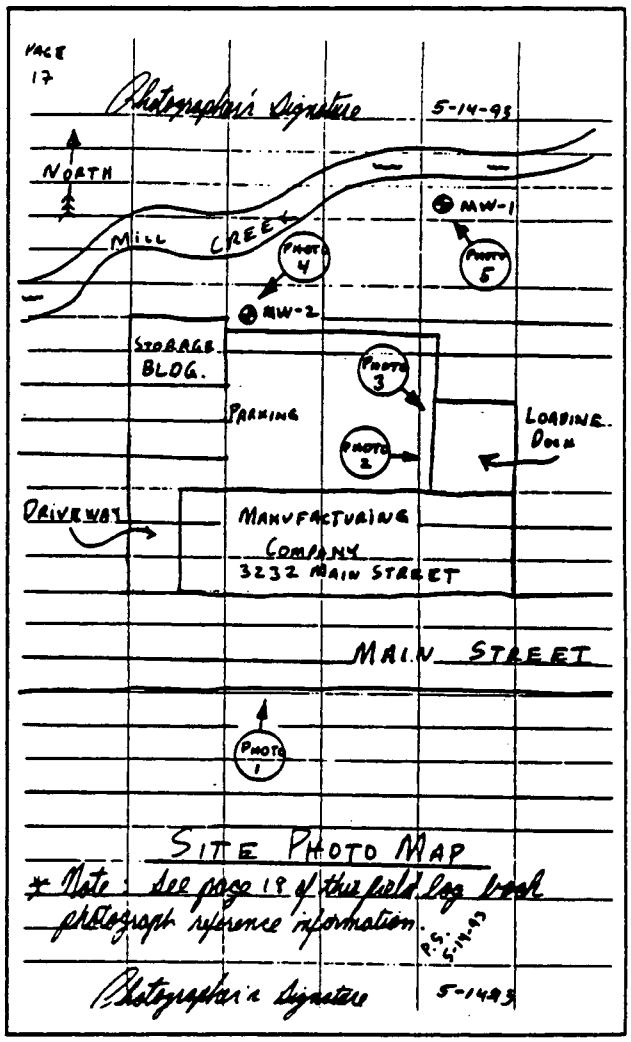


Figure F-1. Site photo map

(4) Sample collection paperwork.

(a) Sample labels. Sample labels are required for properly identifying samples and evidence. The data obtained from samples collected for a sampling or monitoring activity may be used for remedial measures. All samples must be properly labeled with the label affixed to the container prior to transportation to the laboratory. It is also recommended that samples be photographed so that labels are clearly readable for later identification. Information on sample labels should include, but not be limited to, the following:

- Project Code. An assigned contractor, project number, site name.
- Station Number. A unique identifier assigned to a sampling point by the sampling team.
- Sample Identification Number. Each sample, including field control samples, collected for a project should be assigned a unique number. This assigned number incorporates information on the sample type and date (see Section *b*(4)b in Instruction F-1).
- Samplers. Each sampler's name and signature or initials.
- Preservative. Whether a preservative is used and the type of preservative.
- Analysis. The type of analysis requested.
- Date/Time. Identify the date and time the sample was taken.
- Type of Sample. The type of sample should be identified as discrete or composite.

(b) Sample numbering. A sample numbering system should be used to identify each sample collected and submitted for analysis. The purpose of the numbering system is to assist in the tracking of samples and to facilitate retrieval of analytical results. The sample identification numbers for each sampling effort should be used on sample labels, sample tracking matrix forms, chain-of-custody forms, field logbooks, and all other applicable documentation. A listing of all sample identification numbers should be recorded in the field logbook. The sampling numbering system may vary depending upon the number and type of samples that will be collected at the site. An example of a sample numbering system is presented below. Location and sample identification numbers should consist of the following designations to identify the location (AABBB-CC), sample sequence number, date (MMDDYY), and sample interval for soils (00-00):

For Soil and Bedrock: AABBB-CC/MMDDYY/00-00
For Water: AABBB-CC/MMDDYY
For QC Samples: AABBB-CC/MMDDYY

Example: SB001-01/081492/08-10=Soil Boring SB001, Sample Number 1, sampled on August 14, 1992, from a sample interval of 8 to 10 ft.

Duplicate samples should be numbered in sequential order. For example, a duplicate sample collected from the above soil boring example would have a designation as follows:

Example: SB001-02/081492/08-10

Each sample collected must be assigned a unique sample number. Sample numbers should change when the media or location changes. Sample numbers should not change because different analyses are requested. For example, water samples collected at the same location, date, and time for volatile organics, semivolatile organics, and metals analyses would all have the same sample number, although the various sample aliquots would be collected in different containers.

(c) Chain-of-custody. Chain-of-custody procedures provide documentation of the handling of each sample from the time it is collected until it is destroyed. Chain-of-custody procedures are implemented so that a record of sample collection, transfer of samples between personnel, sample shipping, and receipt by the laboratory that will analyze the sample is maintained. Records concerning the cleaning of empty sample containers, container shipment from the laboratory to the site, and security of empty containers at the site should also be maintained. The chain-of-custody (COC) record (Figure F-2) serves as a legal record of possession of the sample. The COC record is initiated with the acquisition of the sample. The COC record remains with the sample at all times and bears the name of the person (field investigator) assuming responsibility for the samples. The field investigator is tasked with ensuring secure and appropriate handling of the bottles and samples. To simplify the COC record and eliminate potential litigation problems, as few people as possible should handle the sample or physical evidence during the investigation. A sample is considered to be under custody if one or more of the following criteria are met:

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME					NO. OF CON-TAINERS								REMARKS
SAMPLERS: (Signature)														
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION									

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	

Figure F-2. Chain-of-custody form

- The sample is in the sampler's possession.
- The sample is in the sampler's view after being in possession.
- The sample was in the sampler's possession and then was locked up to prevent tampering.
- The sample is in a designated secure area.

In addition to the COC record, there is also a COC seal. The COC seal (Figure F-3) is an adhesive seal placed in areas such that if a sealed container is opened, the seal would be broken. The COC seal ensures that no sample tampering occurred between the field and the laboratory analysis.

CUSTODY SEAL	CUSTODY SEAL
Date	Date
Signature	Signature

Figure F-3. Chain-of-custody seal

(d) Transfer of custody and shipment. All sample sets should be accompanied by a COC record. When transferring possession of samples, the individual receiving the samples should sign, date, and note the time that

he/she received the samples on the COC record. This COC record documents transfer of custody of samples from the field investigator to another person, other laboratories, or other organizational units. Samples must be properly packaged for shipment and delivered or shipped to the designated laboratory for analyses. Shipping containers must be secured by using nylon strapping tape and custody seals (Instruction F-2). The custody seals must be placed on the container so that it cannot be opened without breaking the seals. The seal must be signed and dated by the field investigator. When samples are split with a facility, state regulatory agency, or other government agency, the agency representative must sign the COC record, if present. All samples should be accompanied by the COC record. As previously discussed, the U.S. Army Corps of Engineers (USACE) tracking number (e.g., LIMS number) that is used in conjunction with the government QA sample shipment must be written on the QA sample's COC record. The original and one copy of the record will be placed in a plastic bag taped to the inside lid of the secured shipping container. One copy of the record will be retained by the field investigator or project leader. The original record will be transmitted to the field investigator or project leader after samples are accepted by the laboratory. This copy will become a part of the project file. If sent by mail, the package should be registered with return receipt requested. If sent by common carrier, an air bill should be used. Receipts from post offices and air bills should be retained as part of the documentation of the chain of custody. The air bill number or registered mail serial number should be recorded in the remarks section of the COC record.

(e) Sample analysis request. To ensure that proper analysis is performed on the samples, additional paperwork may need to be filled out, as required by the lab performing the analysis. This form identifies samples by number, location, and time collected and allows the collector to indicate the desired analysis. This form should act as a supplement/confirmation to the COC record and lab contacts made prior to the sample event initiation.

(5) EPA CLP variances. In addition to the previously discussed documents, if the site under investigation is an Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) site, the EPA will require the following documents:

(a) Field sheets. Field sheets are forms provided by the EPA that correspond to samples that are anticipated to be collected at the site. Figure F-4 is an example of an EPA field sheet. When working on an EPA activity, the field sheet will replace the sample analysis request form. The field sheet contains information specific to that job site and sample, including, but not limited to the following:

- Activity number.
- Project number.
- EPA sample number.
- Analyses requested.
- Sample container.
- Preservatives.
- Sampler.
- Date and time.
- Sampler's signature.

(b) Sample identification tags. Sample identification tags are distributed as needed to field workers by the field sampling leader. Procedures for sample identification tags vary among EPA regions. Generally, the EPA serial numbers are recorded in the project files, the field logbook, and the document control officer's serialized document logbook. Individuals are accountable for each tag assigned to them. A tag is considered to be in an individual's possession until it has been filled out, attached to a sample, and transferred to another individual along with the corresponding COC record. Sample identification tags are not discarded. If tags are lost, voided, or damaged, the facts are noted in the appropriate field logbook, and the field team leader is notified. Figure F-5 is an example of a typical sample identification tag. Upon the completion of the field activities, unused sample identification tags are returned to the document control officer, who checks them against the list of assigned serial numbers. Tags attached to samples that are split with the owner, operator, agent-in-charge, or a government agency are accounted for by recording the serialized tag numbers on the receipt-for-samples form. Alternatively, the split samples are not tagged but are accounted for on a COC record. Samples are transferred from the sample location to a laboratory or another location for analysis. Before transfer, however, a sample is often separated into fractions, depending on the analysis to be performed. Each portion is preserved in accordance with prescribed procedures and is identified with a separate sample identification tag, which should indicate in the "Remarks" section

```
DRAFT                          FIELD SHEET
          U.S. ENVIRONMENTAL PROTECTION AGENCY,  REGION VII
   ENVIRONMENTAL SERVICES DIV.  25 FUNSTON RD. KANSAS CITY, KS 66115
-------------------------------------------------------------------------
FY: 92 ACTNO: IS38P SAMNO: 012 QCC: F MEDIA: WATER  PL: S P F D
-------------------------------------------------------------------------
ACTIVITY DES: SHAW AVENUE DUMP SITE                    REF LATITUDE:
LOCATION: CHARLES CITY        IA  PROJECT NUM: A41  PT: LONGITUDE:
-------------------------------------------------------------------------
SAMPLE DES: ACID BLANK                                 DATE   TIME  FROM REF PT
LOCATION: CHARLES CITY        IA              BEG:  /  /     :     EAST:
CASE/BATCH/SMO:  /  /        LAB:            END:  /  /     :     NORTH:
STORET/AIRS NO:                                                    DOWN:

ANALYSIS REQUESTED:
CONTAINER       PRESERVATIVE     MGP   NAME
CUBI            5 ML HNO3        WM    METALS


COMMENTS:  FOR SUPERFUND ONLY:  SUBSITE IDENTIFIER:___ OPERABLE UNIT:___




SAMPLE COLLECTED BY : _____
```

Figure F-4. EPA field sheet

that the sample is a split sample. The tag used for water, soil, sediment, and biotic samples contains an appropriate place for identifying the sample as a grab or a composite, the type of sample collected, and the preservative used, if any. The tag used for air samples requires the sampler to designate the sequence number and identify the sample type. Sample identification tags are attached to, or folded around, each sample and are taped in place. After collection, separation, identification and preservation, a sample traffic report is completed and the sample is handled using chain-of-custody procedures discussed in the following sections. If the sample is to be split, aliquots are placed into similar sample containers. Sample identification tags are completed and attached to each split and marked with the tag numbers of the other portions and the word "split." Blank or duplicate samples are labeled in the same manner as "normal" samples. Information on blanks or duplicate samples is recorded in the field logbook.

(c) Sample traffic report. The sample documentation system for the CLP sample preparation program is based on the use of the sample traffic report (TR), a four-part carbonless form printed with a unique sample identification number. One TR and its printed identification number are assigned by the sampler to each sample collected. The three types of TRs currently in use include organic, inorganic dioxin, and high-concentration TRs. Figure F-6 is an example of an organics TR. To provide a permanent record for each sample collected, the sampler completes the appropriate TR, recording the case number, site name or code and location, analysis laboratory, sampling office, dates of sample collection and shipment, and sample concentration and matrix. The sampler enters the

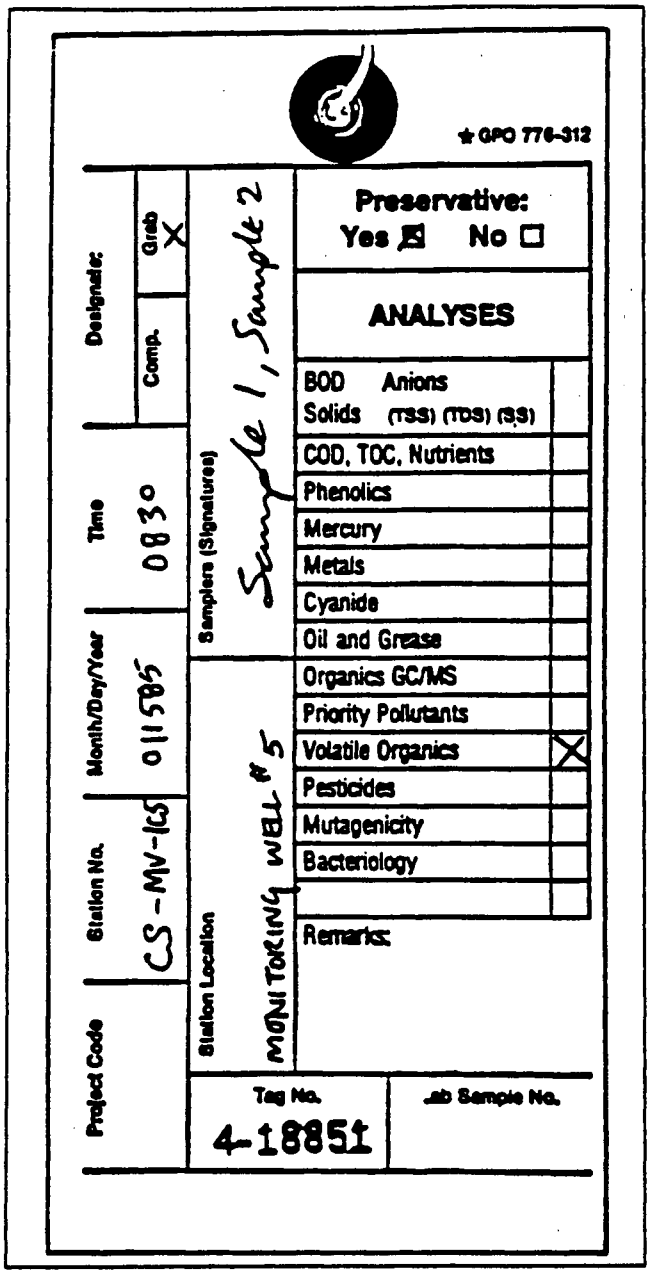


Figure F-5. EPA sample identification tag

numbers of sample containers and volumes beside the analytical parameter(s) requested for particular sample portions. The TR should be placed in the cooler with the COC record and sent to the laboratory.

(d) Receipt-for-samples form. Section 3007(a)(2) of the Resource Conservation and Recovery Act states "If the officer, employee, or representative obtains any samples, prior to leaving the premises, he shall give to the owner, operator, or agent-in-charge, a receipt describing the samples obtained and, if requested, a portion of each such sample equal in volume or weight to the portion retained." Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act (SARA), contains identical requirements. Completing a receipt-for-samples form complies with these requirements; such forms should be used whenever splits are offered or provided to the site owner, operator, or agent-in-charge. Figure F-7 is an example of a typical receipt-for-samples form. This form is completed, and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is given to the field leader and is retained in the project files. In addition, the contractor must provide analytical results from the samples collected to the owner, operator, or agent in charge, as mandated in SARA.

c. QA/QC requirements.

(1) Corrections to documentation. All original data recorded in field logbooks and on sample labels, chain-of-custody records, and receipt-for-samples forms are written in waterproof ink. If an error is made on an accountable document, corrections should be made simply by crossing out the error and entering the correct information. The erroneous information should not be obliterated. Any error discovered on a document should be corrected by the person who made the entry. All corrections must be initialed and dated.

(2) Photographs. The photographer should review the photographs or slides when they return from developing and compare them with the photographic log to confirm that the log and photographs match.

d. Potential problems. Although most sample labels are made with water-resistant paper and are filled out using waterproof ink, inclement weather and general field conditions can affect the legibility of sample labels. It is recommended that after sample labels are filled out and affixed to the sample container, the label should be covered with wide clear tape. This will preserve the label and keep it from becoming illegible. In addition to label protection, chain-of-custody and analysis request forms should be protected when samples are shipped in iced coolers. Typically, these forms should be placed inside a ziplock bag or similar waterproof protection and taped to the inside lid of the secured shipping container with the samples.

ORGANICS TRAFFIC REPORT

Sample Number: AH 719

① Case Number: 9999

Sample Site Name/Code: CHEMICAL SOMP/ $750.75

② SAMPLE CONCENTRATION (Check One)
X Low Concentration
___ Medium Concentration

③ SAMPLE MATRIX (Check One)
X Water
___ Soil/Sediment

④ Ship To:
QER LAB
321 ROAD STREET
SOMETOWN, STATE 12345
Attn: SAMPLER COORDINATOR
[redacted]
Transfer
Ship To:

⑤ Regional Office: [illegible]
Sampling Personnel:
SAMPLER
(Name)
412/788-1080
(Phone)
Sampling Date:
1/15/85
(Begin) (End)

⑥ For each sample collected specify number of containers used and mark volume level on each bottle.

	Number of Containers	Approximate Total Volume
Water (Extractable)	2	1 gal
Water (VOA)	2	80 ml
Soil/Sediment (Extractable)		
Soil/Sediment (VOA)		
Other		

⑦ Shipping Information
FEDERAL EXPRESS
Name of Carrier
1/16/85
Date Shipped:
350262356
Airbill Number:

AH 719	Water (Extractable)
AH 719	Water (Extractable)
AH 719	Water (Extractable)
AH 719	Water (VOA)
AH 719	Water (VOA)
AH 719	Soil/Sediment (Extractable)
AH 719	Soil/Sediment (Extractable)
AH 719	Soil/Sediment (VOA)
AH 719	Soil/Sediment (VOA)

⑧ Sample Description
___ Surface Water ___ Mixed Media
___ Ground Water ___ Solids
___ Leachate ___ Other (specify) _____

⑨ Sample
CS-MW-105
MATCHES ITR # MW 18?

⑩ Special Handling Instructions:
(e.g., safety precautions, hazardous nature)

SMO COPY

Figure F-6. EPA organics traffic report

United States
Environmental Protection Agency
Region 10

RECEIPT FOR SAMPLES

Environmental Services Division
U.S. Environmental Protection Agency Region 10
1200 Sixth Avenue, Seattle, Washington 98101

PROJECT NO.	PROJECT NAME	Name of Facility
SAMPLER(S): (Signature)		Facility Location
Split Samples Offered	( ) Accepted ( ) Declined	

Station Number	Date	Time	Comp.	Grab	Sample Container	Tag Numbers	Station Description	No. of Containers	Remarks

Transferred by: (Signature)		Received by: (Signature)		Telephone Number
Date	Time	Title	Date	Time

Distribution: Original to Coordinator Field Files; Copy to Facility

№ 131

Figure F-7. Receipt for samples form

F-2. Packaging and Shipping Procedures

a. Scope and application. This section describes procedures for properly packaging and shipping environmental and hazardous waste samples. The procedures described in this section are performed after samples have been collected and placed in the proper containers and correctly preserved. Guidelines for proper container and preservative selection can be found in Appendix I.

b. Procedures. The following are procedures for packaging and shipping requirements of environmental and hazardous waste samples.

(1) Environmental samples. Environmental samples are defined as those samples collected from environmental matrices such as soil, groundwater, or sediments. Contaminant levels in these types of samples are normally less than 10 ppm. Environmental samples should be packaged for shipment as follows:

(a) Sample container is adequately identified with sample labels (Section b(4)(a) in Instruction F-1). Sample labels are placed on samples at this time if required.

(b) All bottles, except the volatile organic analysis (VOA) vials, are taped shut with electrical tape (or other tape as appropriate). Evidence tape or custody seals (Figure F-8) may be used for additional sample security.

(c) Each sample bottle is placed in a separate plastic bag, which is then sealed. For water samples, each VOA vial is wrapped in a paper towel, and the two vials are placed in one bag. If a trip blank is submitted, it should be wrapped and placed in the bag with the two VOA

CUSTODY SEAL	CUSTODY SEAL
Date	Date
Signature	Signature

Figure F-8. Typical custody seals

vials. As much air as possible is squeezed from the bag before sealing. Bags may be sealed with evidence tape or custody seals for additional security.

(d) A picnic cooler (such as a Coleman or other sturdy cooler) is typically used as a shipping container. In preparation for shipping samples, the drain plug is taped shut from the inside and outside, and a large plastic bag is used as a liner for the cooler. Approximately 3 in. of inert packing material, such as asbestos-free vermiculite, perlite, or styrofoam beads, is placed in the bottom of the liner. Other commercially available shipping containers may be used. However, the use of such containers (cardboard or fiber boxes complete with separators and preservatives) should be specified in the sampling plan and pre-approved.

(e) The bottles are placed upright in the lined picnic cooler in such a way that they do not touch and will not touch during shipment. Cardboard separators may be placed between the bottles at the discretion of the shipper.

(f) All samples should be shipped to the laboratory on ice and chilled to 4 °C *except* for the following types of samples, which do not require shipment with ice:

- Low- and medium-concentration water and liquid matrix samples for metals analyses.
- Medium-concentration soil and sediment matrix samples for base, neutral, acids (B/N/A), polychlorinated biphenyls (PCBs), and pesticide analyses.

However, because prior knowledge of analyte concentrations is required to apply this exception, it may be prudent to maintain the cooling requirement.

(g) Additional inert packing material is placed in the cooler to partially cover the sample bottles (more than halfway). If samples are required to be shipped to the laboratory with ice, ice in double bags must be placed around, among, and on top of the sample bottles. If chemical ice is used, it should be placed in a double plastic bag. The cooler should then be filled with inert packing material and the liner taped shut.

(h) The paperwork going to the laboratory is placed inside a plastic bag. The bag is sealed and taped to the inside of the cooler lid. A copy of the COC form should be included in the paperwork sent to the laboratory. The last block on the COC form should indicate the overnight carrier and air bill number. The air bill must be filled out before the samples are handed over to the carrier. The laboratory should be notified if another sample is being sent to another laboratory for dioxin analysis or if the shipper suspects that the sample contains any other substance that would require laboratory personnel to take additional safety precautions.

(i) The cooler is closed and taped shut with strapping tape (filament-type).

(j) At least two signed custody seals are placed on the cooler, one on the front and one on the side. Additional seals may be used if the sampler or shipper thinks more seals are necessary.

(k) The cooler is handed over to the overnight carrier. A standard air bill is necessary for shipping environmental samples. The shipper should be aware of carrier weight or other policy limitations.

(2) Hazardous samples. Hazardous samples are defined as those which are typically highly contaminated, such as oils, sludges, discarded products, and other materials. Contaminant levels in these types of samples are normally greater than 10 ppm. Hazardous samples must be packaged as follows:

(a) Sample container is adequately identified with sample labels (Section b(4)(a) in Instruction F-1). Sample tags are placed on samples at this time if required.

(b) All bottles, except the VOA vials, are taped closed with electrical tape (or other tape as appropriate). Evidence tape or custody seals may be used for additional security.

(c) Each sample bottle is placed in a plastic bag, and the bag is sealed. As much air as possible is squeezed from the bags before sealing. Evidence tape or custody seals may be used to seal the bags for additional security.

(d) Each bottle is placed upright in a separate paint can, the paint can is filled with vermiculite, and the lid is fixed to the can. The lid must be sealed with metal clips or with filament or evidence tape; if clips are used, the manufacturer typically recommends six clips.

(e) Arrows are placed on the can to indicate which end is up.

(f) The outside of each can must contain the proper Department of Transportation (DOT) shipping name and identification number for the sample. The information may be placed on stickers or printed legibly. A liquid sample of an uncertain nature is shipped as a flammable liquid with the shipping name "FLAMMABLE LIQUID, N.O.S." and the identification number "UN1993." A solid sample of uncertain nature is shipped as a flammable solid with the shipping name "FLAMMABLE SOLID, N.O.S." and the identification number "UN1325." If the nature of the sample is known, 40 CFR 171-177 is consulted to determine the proper labeling and packaging requirements.

(g) The cans are placed upright in a cooler that has had its drain plug taped shut inside and out, and has been lined with a garbage bag. Vermiculite is placed on the bottom. Two sizes of paint cans are used: half-gallon and gallon. The half-gallon paint cans can be stored on top of each other; however, the gallon cans are too tall to stack.

(h) All hazardous samples should be shipped to the laboratory on ice and chilled to 4 °C, except for the following samples which do not require shipment with ice:

- Medium concentration water and liquid matrix samples for metals analysis.
- Medium concentration soil and sediment matrix samples for B/N/A, PCBs, and pesticide analyses.

However, because prior knowledge of the analyte concentrations is required to apply this exception, it may be prudent to maintain the cooling requirement.

(i) Additional inert packing material is placed in the cooler to partially cover the sample bottles. If samples are required to be shipped to the laboratory with ice, bags of ice must be placed around the cans. The cooler must be filled with packing material and the liner taped shut.

(j) The paperwork going to the laboratory is placed inside a plastic bag and taped to the inside of the cooler lid. A copy of the COC form should be included in the paperwork sent to the laboratory. The sampler keeps one copy of the COC form. The laboratory should be notified if a parallel sample is being sent to another laboratory for dioxin analysis, or if the sample is suspected of containing any substance for which laboratory personnel should take safety precautions.

(k) The cooler is closed and sealed with strapping tape. At least two custody seals are placed on the outside of the cooler (one on the front and one on the back). More custody seals may be used at the discretion of the sampler.

(l) The following markings are placed on the top of the cooler:

- Proper shipping name (49 CFR 172.301).
- DOT identification number (49 CFR 172.301).
- Shipper's or consignee's name and address (49 CFR-172.306).
- "This End Up" legibly written if shipment contains liquid hazardous materials (49 CFR 172.312).

(m) The following labels are required on top of the cooler (49 CFR 172.406(e)):

- Appropriate hazard class label (placed next to the proper shipping name).
- "Cargo Aircraft Only" (if applicable as identified in 49 CFR 172.101).

(n) An arrow symbol(s) indicating "This Way Up" should be placed on the cooler in addition to the markings and labels described above.

(o) Restricted-article air bills are used for shipment. The "Shipper Certification for Restricted Articles" section is filled out as follows for flammable solid or a flammable liquid:

- Number of packages or number of coolers.
- Proper shipping name: if unknown, use
  - Flammable solid, N.O.S., or
  - Flammable liquid, N.O.S.

- Classification; if unknown, use
  - Flammable solid, N.O.S., or
  - Flammable liquid, N.O.S.
- Identification number; if unknown, use
  - UN1325 (for flammable solids), or
  - UN1993 (for flammable liquids).
- Net quantity per package or amount of substance in each cooler.
- Radioactive materials section (Leave blank).
- Passenger or cargo aircraft. (Cross off the non-applicable. Up to 25 lb of flammable solid per cooler can be shipped on a passenger or cargo aircraft. Up to 1 qt of flammable liquid per cooler can be shipped on a passenger aircraft, and up to 10 gal of flammable liquid per cooler can be shipped on a cargo aircraft.)
- Name and title of shipper (printed).
- An emergency telephone number at which the shipper can be reached within the following 24 to 48 hr.
- Shipper's signature.

c. Sample containers and preservatives. Appendix I provides information concerning sample containers and preservatives.

Appendix G
Analytical Techniques/Procedures Instructions

G-1. Metals Analysis By Inductively Coupled Plasma (ICP)

a. Scope. This analytical instruction shall serve U.S. Army Corps of Engineers (USACE) and/or contracted personnel during the generation of the sampling and analysis plan (SAP) in the specification of requirements with regard to trace metals analysis. This instruction is intended to be used, in conjunction with Appendix B, "Chemical Analysis Requirements," and the appropriate digestion and analytical standard methods, to describe the management policies, objectives, principles, and procedures used to generate metals data of the required quality. The methods identified within this instruction which may be used for trace metal determination, are drawn from the following references:

(1) Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW-846, Third Edition, Update 1, Revision 1 (1990), Method 6010A.

(2) U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Statement of Work for Inorganics Analysis, Document No. HC01.2, Method ILM01.

(3) Methods for the Determination of Metals in Environmental Samples, EPA 600/4-91/010, June 1991, Method 200.7. This revision REPLACES THE FOLLOWING: Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, March 1983, Method 200.7.

b. Application.

(1) The analytical methods are applicable to all environmental matrices with appropriate preparatory and/or digestion procedures, for the determination of dissolved, suspended, leachable, total, or total recoverable metals. Applicability of the individual methods to a project will depend upon the regulating authority the project is being performed under, as well as the level of data quality required to support the data needs and decisions of the project. Generally speaking, EPA 200 series methods were promulgated for support of monitoring metals under the Safe Drinking Water Act (SDWA) and National Pollutant Discharge Elimination System. Typically, samples taken under the jurisdiction of these programs are groundwater or surface waters that are fairly free of interferences. Methods required under this law, accordingly, do not require the rigorous level of quality control (QC) associated with other programs and methods, but may require substantially lower detection limits. CLP methods were developed as an integral portion of the Superfund program, outlining specifically all contract laboratory responsibilities and reportables. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-Superfund and the associated CLP support program provide liability compensation, cleanup, and emergency responses for hazardous substance releases into the environment, and the cleanup of inactive hazardous waste disposal sites. Due to the likelihood of eventual litigation associated with these projects, CLP has very strict procedures outlined for sample custody, documentation requirements, data validation, and reportables. These requirements also tend to elevate the cost per sample. SW-846 was promulgated to support evaluations and measurements needed to comply with the Resource Conservation and Recovery Act (RCRA) and 40 CFR 122 - 270. These methods provide technical assistance for the recovery of energy, for the safe disposal of discarded materials, and/or to regulate the management of hazardous wastes. Technically, CLP methods are very similar to SW-846, in that they both have the method options, cleanup procedures, etc., to deal with hazardous waste samples that potentially exhibit numerous interferences during analysis. All of the methods are based on the same instrumentation and technique. However, each method is unique, with individual requirements for analysis, sensitivity, quality control, and acceptance criteria which must be maintained. Each particular method's requirements should be evaluated for applicability toward a project based upon project data needs, the required sensitivity, and/or level of quality of that data. The required level of QC may also be modified (either more or less stringent) based upon project requirements. All deviations must be agreed to by all parties involved.

(2) Deciding the applicable metals to be investigated for the project is dependent upon past operations, disposal practices, and/or general data needs. Guidance on this subject may be obtained from USACE instructions on project planning.

(3) Additional instructions and Table G-1 should be referenced for an outline of the applicable procedures for metals sample preparation, digestion, or dissolution. Requirements for sample containers, preservatives, and holding times may be found in Appendix I. Definitions of key words used in these instructions may be found in

Table G-1
Applicable Digestion Procedure Methodologies or Sections

Matrix	Measurement	SW-846	CLP	EPA600	Analysis
Water	Total Recov.	3005	Exhibit D Section III, A	200.7,9.4	ICP or FLAA
Water	Total	3010		200.7,9.3	ICP or FLAA
Water	Total	3020			GFAA
Water	Dissolved	3005		200.7,9.1 and/or 9.3	ICP or FLAA
Soils Sediments Sludges	Total	3050	Exhibit D Section III, B	-	ICP, FLAA
Dissolution Procedure					
Oils Greases Waxes	Total	3040	-	-	ICP or FLAA

Appendix J. Tables G-2, G-3, and G-4 present listings of elements that may be analyzed by a particular method and corresponding detection limit requirements as established within that method. Project-specific Practical Quantitation Limits (PQL) shall be identified based upon project objectives, and technical feasibility of instrumentation. Refer to paragraph 4*c*(6) of Appendix B for guidance on this subject. Project PQLs should be established at levels, at least two times greater than the method-specified method detection limits (MDLs), and should be between two to five times greater than the specified instrument detection limits (IDLs). Table G-2 is a list of estimated PQLs for both water and soil matrices for SW-846 method 6010A. The remaining tables (G-3 and G-4) present only the limits prescribed within the methods for contractual purposes, or for the reagent water matrix, respectively.

(4) The instructions presented here may be used as written, or be modified based upon project requirements. In order to utilize the instruction, the contractor and/or USACE technical personnel, should identify the appropriate method to follow, noting any special requirements or variations from that method, and document this information within the SAP.

c. Inductively Coupled Argon Plasma (ICAP) emission spectroscopy batch QA/QC requirements. The following text details further the sequential batch quality assurance (QA)/QC requirements outlined in Table G-5 for each of the methods identified in paragraph 1.0.

(1) Calibration. Each ICP will be calibrated after becoming thermally stable, and prior to any analyses. The calibration requirements differ depending upon the method, and often reference the instrument manufacturer's recommendations. For this reason, clarification is made here to ensure a uniform approach to trace metals analysis. Due to the considerable linear range required for ICP analysis, USACE has developed minimum calibration requirements as follows: The calibration curve should be established daily by analyzing standards at a minimum of **three** concentration levels and an initial calibration blank (ICB).

(2) Rerun highest standard. Prior to sample analysis, certain references (method 6010A and 200.7) require the reanalysis of the highest calibration standard for all elements under analysis. Concentration values must fall within the criteria noted in order to continue the analysis.

(3) Initial calibration verification. The calibration curve is then verified using the initial calibration verification standard (ICV) (a.k.a. instrument check standard) and ICB. This standard may be an EPA-certified multi-element standard or independently prepared multi-element standard solution. This standard prepares all elements at concentrations of known concentrations equivalent to the midpoint of their respective calibration curves and must be run at each wavelength used in the ICP analysis. The results of these standards must fall within the criteria noted on Table G-5 to confirm that the analysis is being performed in control. If the criteria are not achieved, the analysis is terminated, the problem corrected, and the instrument recalibrated.

Table G-2
Element List and Reporting Limits for Metals by ICP (6010A, EPA SW-846, 3rd Edition, Update 1, Rev. 1, November 1990)

		Practical Quantitation Limits[1]		
Metals	CAS Number	IDLs(µg/L)[2]	Water (µg/L)	Soil (mg/kg)
1. Aluminum	7429-90-5	45	90	9
2. Antimony	7440-36-0	32	64	6
3. Arsenic	7440-38-2	53	100	10
4. Barium	7440-39-3	2	4	0.4
5. Beryllium	7440-41-7	0.3	0.6	0.06
6. Cadmium	7440-43-9	4	8	0.8
7. Calcium	7440-70-2	10	100	10
8. Chromium	7440-47-3	7	14	1
9. Cobalt	7440-48-4	7	14	1
10. Copper	7440-50-8	6	12	1
11. Iron	7439-89-6	7	14	1
12. Lead	7439-92-1	42	82	8
13. Lithium	7439-93-2	5	10	1
14. Magnesium	7439-95-4	30	60	6
15. Manganese	7439-96-5	2	4	0.4
16. Molybdenum	7439-98-7	8	16	2
17. Nickel	7440-02-0	15	30	3
18. Phosphorus	7723-14-0	51	100	10
19. Potassium	7440-09-7100		10	
20. Selenium	7782-49-2	75	150	15
21. Silver	7440-22-4	7	14	1
22. Sodium	7440-23-5	29	58	58
23. Strontium	7440-24-6	0.3	0.6	0.06
24. Thallium	7440-28-0	40	80	8
25. Vanadium	7440-62-2	8	16	2
26. Zinc	7440-66-6	2	4	0.4

[1]Practical quantitation limits (PQLs) determined for samples vary dependant upon the sample matrix. USACE has established these levels as estimated PQLs to follow.
[2]Instrument detection limits (IDLs) shown are a guide for an instrumental limit at the wavelengths recommended within the method.

Table G-3
Element List and Reporting Limits for Metals by ICP-AES (USEPA Contract Laboratory Program Statement of Work for Inorganics Analysis Document No. HC01.2 Method ILM01)

Metals	CAS Number	Contractor Required Detection Limits (µg/L)[1]
1. Aluminum	7429-90-5	200
2. Antimony	7440-36-0	60
3. Arsenic	7440-38-2	10
4. Barium	7440-39-3	200
5. Beryllium	7440-41-7	5
6. Cadmium	7440-43-9	5
7. Calcium	7440-70-2	5000
8. Chromium	7440-47-3	10
9. Cobalt	7440-48-4	50
10. Copper	7440-50-8	25
11. Iron	7439-89-6	100
12. Lead	7439-92-1	3
13. Magnesium	7439-95-4	5000
14. Manganese	7439-96-5	15
15. Nickel	7440-02-0	40
16. Potassium	7440-09-7	5000
17. Selenium	7782-49-2	5
18. Silver	7440-22-4	10
19. Sodium	7440-23-5	5000
20. Thallium	7440-28-0	10
21. Vanadium	7440-62-2	50
22. Zinc	7440-66-6	20

[1]IDLs are determined by each laboratory individually on a per instrument basis, and confirmed quarterly. Contractor-required detection limits (CRDLs) are contractually binding limits and are not instrument specific. According to CLP, Section II, these limits must be accomplished for samples using ICAP or AA methods.

(4) Interference check standard. The interference (inter-element) check standard/inter-element correction standard (ICS/IEC) shall be analyzed at the beginning (and end) of each analytical batch to verify inter-element and background correction factors. The solution contains both interfering and analyte elements of known concentrations to exhibit background and/or inter-element interferences, so that appropriate instrumental correction factors may be established to compensate. If method-specific criteria have not been achieved, the analysis should be terminated, corrective action should be initiated, and the instrument should be recalibrated.

(5) Continuing calibration verification. After successful completion of the above criteria, analysis of field samples can begin. An ensuing method QC requirement to the commencement of sample analysis is the verification of the calibration curve every 10 field samples. Results from the analysis of the continuing calibration blank (CCB) and a continuing calibration verification

Table G-4
Element List and Reporting Limits for Metals by ICP (200.7, EPA 600/4-91-010, June 1991)

Metals	CAS Number	Instrument Detection Limits[1] Water (µg/L)
1. Aluminum	7429-90-5	45
2. Antimony	7440-36-0	32
3. Arsenic	7440-38-2	53
4. Barium	7440-39-3	2
5. Beryllium	7440-41-7	0.3
6. Boron	7440-42-8	5
7. Cadmium	7440-43-9	4
8. Calcium	7440-70-2	10
9. Chromium	7440-47-3	7
10. Cobalt	7440-48-4	7
11. Copper	7440-50-8	6
12. Iron	7439-89-6	7
13. Lead	7439-92-1	42
14. Magnesium	7439-95-4	30
15. Manganese	7439-96-5	2
16. Molybdenum	7439-98-7	8
17. Nickel	7440-02-0	15
18. Potassium	7440-09-7	75
19. Selenium	7782-49-2	75
20. Silica (SiO_2)	7631-86-9	58
21. Silver	7440-22-4	7
22. Sodium	7440-23-5	29
23. Thallium	7440-28-0	40
24. Vanadium	7440-62-2	8
25. Zinc	7440-66-6	2

[1]Estimated instrument detection limits as shown are a guide for an instrumental limit at the wavelengths recommended within the method. Actual quantitation limits determined for samples vary dependant upon the sample matrix.

(CCV) standards must meet the method-established criteria stated in Table G-5. If the verification standards or blank do not meet the established criteria, corrective action must be performed which may include recalibration and reanalysis of samples back to the previous acceptable calibration check.

(6) Batch QC sample analysis. Batch QC samples include method blanks, laboratory control samples (LCSs), duplicates, matrix spike (MS), and matrix spike duplicates (MSD). Reference appendix J for definitions of these QC samples. Analysis of these samples provides insight into

Table G-5
Requirements for Trace Metal Analysis by ICAP

		Minimum Criteria	
Sample/Procedure	SW-846	CLP	EPA-600
	Preliminary QC Requirements		
Instrument set-up thermally stable	30 min	30 min.	30 min.
ICB	✓	✓	✓
3 Calibration Stds	✓	daily	✓
Rerun Highest Std	±5%	-	±5%
ICV	±10%	±10%	±5%
ICB	±2 sigma of mean blank value	<IDL[1] <CRDL	±2 sigma of mean blank value
ICS (IEC)	±20%	±20%	±1.5 sigma of mean value
	Continuing Calibration Verification Samples (Required Every 10 Field Samples)		
CCV	±10%	±10%	±5%
CCB	±3 sigma of mean blank value	<IDL[1] <CRDL	±3 sigma of mean blank value
	Batch QC Samples (Required Every 20 Field Samples)		
MB	<MDL	<CRDL	-
LCS	-	%R = 80-120	-
	Batch QC Samples Continued (Required Every 20 Field Samples)		
Duplicate (DUP)	RPD <20%	RPD <20%	-
MS	%R = 75-125	%R = 75-125	-
MSD	RPD <20	-	-
	Requirements When New or Unusual Matrix Encountered:		
Serial dilution	±10%	±10%	±5%
Method of Standard Additions	✓	-	-

(Continued)

[1]If the value of the ICB/CCB exceeds the IDL, this information must be submitted via a particular form. If the ICB/CCB exceeds the CRDL, the analysis must be terminated, corrective action must be taken, and the instrument must be recalibrated.
- Not required/Criteria not specified
✓ Required within method as noted with no further clarification
CRDL = Contractor-required detection limit
MB = Method blank
RPD = Relative percent difference

Table G-5 (Concluded)

Sample/Procedure	SW-846	Minimum Criteria[1] CLP	EPA-600
	Final Verification Samples (Required at the End of the Run)		
CCV	±10%	±10%	±5%
CCB	±2 sigma of mean blank value	<IDL[1] <CRDL	±2 sigma of mean value
ICS (IEC)	±20%	±20%	±1.5 sigma of mean value

the precision and accuracy of the analytical run and of the performance in association with the matrix under investigation. Required frequency and acceptance criteria are presented in Table G-5.

(7) Procedural requirements for new or unusual matrix. When a new or unusual matrix is encountered, a series of tests is recommended prior to release of results to verify that matrix effects are occurring. The method recommends that a 1:4 dilution of the sample be prepared and run if samples exhibit a concentration >10 x IDL. Results of the sample dilution run(s) must agree to within ± 10 percent of the original determination. If results do not meet the established criteria, additional procedures must be performed in order to determine the concentration of the sample. The additional procedure required is analysis of the sample by the method of standard additions.

(8) Final verification. A number of QC samples are also required at the end of an analytical run to corroborate that the method of analysis has remained in an "in control" mode of operation. Final calibration verification through analysis of the CCV/CCB and verification of inter-element and background correction factors with the analysis of an interference (inter-element) check standard (ICS/IEC) are required. The required acceptance criteria are presented in Table G-5. If any of the final verification standards or blanks do not meet the established criteria, corrective action must be performed, which may include recalibration and reanalysis of samples back to the previous acceptable calibration (of inter-element) check.

d. Outline for reporting requirements. As noted in paragraph *c* of this instruction, numerous items must be checked against method-specific criteria in order to determine the acceptability of the metals data and the analytical run as a whole. In order that USACE may confirm the quality of the data received, much of this information must be relayed along with the sample results in order to complete an independent review or validation of the data. These data-reporting package requirements must be clearly defined within the SAP. Two data-reporting formats may be anticipated for use with USACE projects: (1) a data package that is forecast to be submitted to the USACE Quality Assurance Laboratory for chemical quality assurance report (CQAR) generation, and (2) a fully validatable package (e.g., similar to CLP). The contract laboratory is required to submit the required data package to appropriate personnel, as identified within the SAP, for review and validation, respectively. The following outline addresses only (1) the submittal required by the USACE quality assurance (QA) laboratory in order that the project CQAR be generated. Refer to the USACE Functional Guidelines for Data Validation for the requirements of the (2) fully validatable data package. Reference paragraph 11*d* of Appendix B for specific details on the subject results identified below.

(1) Case narrative.

(2) Sample results.

(3) Initial and continuing calibration blank.

(4) Initial and continuing calibration verification standard.

(5) Interference check standard.

(6) Method blank.

(7) Laboratory control sample.

(8) Matrix duplicate.

(9) Matrix spike.

(10) Matrix spike duplicate.

(11) Serial dilution.

(12) Method of standard additions.

e. Recommended collection volumes for metal determinations.

Matrix	Measurement	Digest./Prep. Vol./Wt.	&	Collect. Vol/Wt.
Water	Total Recov.	100 mL		1,000 mL
Water	Total	100 mL		1,000 mL
Water	Dissolved	100 mL		1,000 mL
Soils/ Sediment	Total	2 gm		200 gm

f. Decontamination requirements. Proper decontamination for equipment utilized in conjunction with metals acquisition and analysis is as follows:

(1) Wash with detergent water to remove all particles.

(2) Rinse with tap water.

(3) Rinse with 1:1 nitric acid (do not soak).

(4) Rinse with tap water.

(5) Rinse with 1:1 hydrochloric acid (do not soak).

(6) Rinse with tap water.

(7) Rinse with ASTM II water.

G-2. Volatile Organics Analysis By Gas Chromatography/Mass Spectrometry (GC/MS)

a. Scope. This analytical instruction shall serve USACE and/or contracted personnel during the generation of the SAP in the specification of requirements with regard to volatile organics analysis. This instruction is intended to be used in conjunction with Appendix B, "Chemical Analysis Requirements," and the appropriate standard analytical method to describe the management policies, objectives, principles, and procedures used to generate volatile organics data of the required quality. The methods identified within this instruction may be used for the determination of low level purgeable volatile organics and are drawn from the following references:

(1) Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW-846, Third Edition, Update 2, Revision 1 (November 1990), method 8260A.

(2) USEPA Contract Laboratory Program (CLP) Statement of Work for Organic Analysis, Document No. OLM01.0 (Jan 1991).

(3) USEPA Contract Laboratory Program (CLP) Statement of Work for Low Concentration Water for Organics Analysis, 10/92.

(4) Methods for the Determination of Organic Compounds in Drinking Water, EPA 600/4-88-039, December 1988 (Revised July 1991), method 524.2 (revision 3.0). Addresses the water matrix only.

b. Application.

(1) Applicability of particular matrices varies among the analytical methods identified above. SW-846 and CLP are applicable to nearly all environmental matrices, while the 500 series methodology is limited to drinking or raw source waters for the determination of low-level volatile organic compounds. The relevancy of a particular method to the project will be dependant upon the regulating authority the project is being performed under, the target analyte listing of interest, as well as the level of data quality required to support the data needs and decisions of the project. Generally speaking, EPA 500 series methods were promulgated for support of monitoring under the SDWA and NPDES. Typically, samples taken under the jurisdiction of these programs are groundwater or surface waters that are fairly free of interferences. Methods required under this law, accordingly, do not require the rigorous level of QC associated with other programs and associated methods, but may require substantially lower detection limits. CLP methods were developed as an integral portion of the Superfund program, outlining specifically all contract laboratory responsibilities and reportables. The CERCLA-Superfund and the associated CLP support program provide liability compensation, cleanup, and emergency responses for hazardous substance releases into the environment; and the cleanup of inactive hazardous waste disposal sites. Due to the likelihood of eventual litigation associated with these projects, CLP has very strict procedures for sample custody, documentation requirements, data validation, and reportables. These requirements also tend to elevate the cost per sample. CLP has also recently released a low-level water method, which is also incorporated into this instruction, in addition to the original CLP methodology. SW-846 was promulgated to support evaluations and measurements needed to comply with RCRA and 40 CFR 122 - 270. These methods provide technical assistance

for the recovery of energy, for the safe disposal of discarded materials, and/or to regulate the management of hazardous wastes. Technically, CLP methods are very similar to SW-846, in that they both have the method options, cleanup procedures, etc., to deal with hazardous waste samples that potentially exhibit numerous interferences during analysis. All of the methods are based on the same general instrumentation and technique. However, each method is unique, with individual requirements for analysis, sensitivity, quality control, and acceptance criteria which must be maintained. Each particular method's requirements should be evaluated for applicability toward a project based upon project data needs, required sensitivity, and/or the level of quality of that data. The required level of QC may also be modified (either more or less stringent) based upon project requirements. All deviations must be agreed to by all parties involved.

(2) Deciding the applicable volatile organic analysis (VOA) method for the project is dependent upon past operations, disposal practices, and/or general data needs. Guidance on this subject may be referenced from USACE guidance on project planning.

(3) Requirements for sample containers, preservatives, and holding times may be referenced from Appendix I. Definitions of key words used in this instruction may be found in Appendix J. Tables G-6, G-7, and G-8 present a listing of applicable constituents each method is capable of analyzing, and corresponding detection limit requirements for volatile organics analysis by GC/MS following the noted methods. Project-specific PQL shall be identified based upon project objectives, and technical feasibility of instrumentation. Refer to paragraph 4*c*(6) of Appendix B for guidance on this subject. Project PQLs should be established at levels at least two times greater than the method-specified MDLs, and should be between two and five times greater than the specified IDLs.

(4) The instructions may be used as written, or may be modified based upon project requirements. In order to utilize the instruction, the contractor and USACE technical personnel should identify the appropriate method to follow, noting any special requirements or variations from that method within the SAP.

c. Summary GC/MS batch quality assurance (QA)/QC sample requirements. The following text details further the sequential batch QC requirements outlined in Table G-9 for each of the methods identified in paragraph 1.0.

(1) Column and trap conditioning. Method requirements vary the recommendations for daily conditioning, but each require at a minimum the requirements established in Table G-9.

(2) Tuning criteria. The GC/MS system must initially be tuned with a suitable calibrant according to manufacturer's specifications. The instrument calibration is then confirmed with 50 ng. of bromofluorobenzene (BFB) for volatile compounds. No samples are analyzed until the instrument has met the tuning criteria according to the specific method table noted.

(3) Sensitivity check. Method 524.2 requires an initial run of the midpoint standard to verify the GC performance and MS sensitivity according to the criteria noted.

(4) Calibration. All methods require analysis of the appropriate standards, prepared fresh daily, to establish the calibration range. For method 524.2, the number of calibration standards required varies between 3 and 5, depending upon the extent of the calibration range desired. Both 8260A and CLP require five standards. The low level concentration standard requirements vary substantially among different methods. Method 8260 requires that the standard be near, but above the MDL. Method 524.2 requires that the standard be in the range of 2 to 10 times the MDL. CLP requires the standard run at the method's established contractor-required quantitation limit (10 µg/L or 1 µg/L). An initial calibration curve shall be produced if (relative) response factors and percent RSD results meet the criteria established within each method. This resulting calibration curve defines the working range and retention time windows and criteria for identification according to the procedures noted in Table G-9.

(5) Continuing calibration. The GC/MS initial calibration must be periodically evaluated at the frequency defined in Table G-9 to ensure that the system is within calibration and to reestablish analyte retention time windows. This encompasses analysis of 50 ng of bromofluorobenzene to confirm correct mass abundances, and analysis of a midpoint standard. If the BFB or daily standard does not meet the criteria noted, the system shall require the establishment of another initial calibration curve.

(6) Preliminary GC/MS QC requirements. Prior to the analysis of samples following methods 8260A and 524.2, low background contribution must be verified; and

Table G-6
Compound List and Reporting Limits for Volatile Organics by GC/MS
(8260A, EPA SW-846, 3rd Edition, Update 1, Rev. 1, November 1990)

Volatiles	CAS Number	MDL (µg/L)	Practical Quantitation Limits	
			Water (µg/L)	Soil (µg/kg)
1. Benzene	71-43-2	0.04	1	5
2. Bromobenzene	108-86-1	0.03	1	5
3. Bromochloromethane	74-97-5	0.04	1	5
4. Bromodichloromethane	75-27-4	0.08	1	5
5. Bromoform	75-25-2	0.12	1	5
6. Bromomethane	74-83-9	0.11	1	5
7. *n*-Butylbenzene	104-51-8	0.11	1	5
8. *sec*-Butylbenzene	135-98-8	0.13	1	5
9. *tert*-Butylbenzene	98-06-6	0.14	1	5
10. Carbon Tetrachloride	56-23-5	0.21	2	10
11. Chlorobenzene	108-90-7	0.04	1	5
12. Chloroethane	75-00-3	0.1	1	5
13. Chloroform	67-66-3	0.03	1	5
14. Chloromethane	74-87-3	0.13	1	5
15. 2-Chlorotoluene	95-49-8	0.04	1	5
16. 4-Chlorotoluene	106-43-4	0.06	1	5
17. Dibromochloromethane	124-48-1	0.05	1	5
18. 1,2-Dibromo-3-chloropropane	96-12-8	0.26	2	10
19. 1,2-Dibromoethane	106-93-4	0.06	1	5
20. Dibromomethane	74-95-3	0.24	2	10
21. 1,2-Dichlorobenzene	95-50-1	0.03	1	5
22. 1,3-Dichlorobenzene	541-73-1	0.12	1	5
23. 1,4-Dichlorobenzene	106-46-7	0.03	1	5
24. Dichlorodifluoromethane	75-71-8	0.10	1	5
25. 1,1-Dichloroethane	75-34-3	0.04	1	5
26. 1,2-Dichloroethane	107-06-2	0.06	1	5
27. 1,1-Dichloroethene	75-35-4	0.12	1	5
28. *cis*-1,2-Dichloroethene	156-59-2	0.12	1	5
29. *trans*-1,2-Dichloroethene	156-60-5	0.06	1	5
30. 1,2-Dichloropropane	78-87-5	0.04	1	5
31. 1,3-Dichloropropane	142-28-9	0.04	1	5
32. 2,2-Dichloropropane	594-20-7	0.35	3	15
33. 1,1-Dichloropropene	563-58-6	0.10	1	5
34. Ethylbenzene	100-41-4	0.06	1	5
35. Hexachlorobutadiene	87-68-3	0.11	1	5
36. Isopropylbenzene	98-82-8	0.15	1	5
37. *p*-Isopropyltoluene	99-87-6	0.12	1	5
38. Methylene chloride	75-09-2	0.03	1	5
39. Naphthalene	91-20-3	0.04	1	5
40. *n*-Propylbenzene	103-65-1	0.04	1	5
41. Styrene	100-42-5	0.04	1	5
42. 1,1,1,2-Tetrachloroethane	630-20-6	0.05	1	5
43. 1,1,2,2-Tetrachloroethane	79-34-5	0.04	1	5
44. Tetrachloroethene	127-18-4	0.14	1	5
45. Toluene	108-88-3	0.11	1	5
46. 1,2,3-Trichlorobenzene	87-61-6	0.03	1	5
47. 1,2,4-Trichlorobenzene	120-82-1	0.04	1	5
48. 1,1,1-Trichloroethane	71-55-6	0.08	1	5

(Continued)

Notes: 1. Other requirements:
a. Reporting will include a computer search with identification and quantitation of the ten highest non-targeted peaks.
b. Holding times before analysis: 14 days from sample collection in the field if preserved; 7 days if not preserved.
c. Sample preservation requirements: pH < 2 with HCl (water only), chilled to 4°C, no headspace. Chemical preservation will be checked at time of sample analysis.
d. MDL expressed on a sample purge volume of 25 mL.

Table G-6 (Concluded)

Volatiles	CAS Number	MDL (µg/L)	Practical Quantitation Limits	
			Water (µg/L)	Soil (µg/kg)
49. 1,1,2-Trichloroethane	79-00-5	0.10	1	5
50. Trichloroethene	79-01-6	0.19	2	10
51. Trichlorofluoromethane	75-69-4	0.08	1	5
52. 1,2,3-Trichloropropane	96-18-4	0.32	3	15
53. 1,2,4-Trimethylbenzene	95-63-6	0.13	1	5
54. 1,3,5-Trimethylbenzene	108-67-8	0.05	1	5
55. Vinyl chloride	75-01-4	0.17	2	10
56. *o*-Xylene	95-47-6	0.11	1	5
57. *m*-Xylene	108-38-3	0.05	1	5
58. *p*-Xylene	106-42-3	0.13	1	5

Table G-7
Compound List and Reporting Limits for Volatile Organics by GC/MS
(CLP Statement of Work for Organic Analysis, OLM01.0)

Volatiles	CAS Number	Contractor-Required Quantitation Limits	
		Water (µg/L)	Soil (µg/kg)
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl Chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene Chloride	75-09-2	10	10
6. Acetone	67-64-1	10	10
7. Carbon Disulfide	75-15-0	10	10
8. 1,1-Dichloroethene	75-35-4	10	10
9. 1,1-Dichloroethane	75-34-3	10	10
10. 1,2-Dichloroethene (total)	540-59-0	10	10
11. Chloroform	67-66-3	10	10
12. 1,2-Dichloroethane	107-06-2	10	10
13. 2-Butanone	78-93-3	10	10
14. 1,1,1-Trichloroethane	71-55-6	10	10
15. Carbon Tetrachloride	56-23-5	10	10
16. Bromodichloromethane	75-27-4	10	10
17. 1,2-Dichloropropane	78-87-5	10	10
18. *cis*-1,3-Dichloropropene	10061-01-5	10	10
19. Trichloroethene	79-01-6	10	10
20. Dibromochloromethane	124-48-1	10	10
21. 1,1,2-Trichloroethane	79-00-5	10	10
22. Benzene	71-43-2	10	10
23. *trans*-1,3-Dichloropropene	10061-02-6	10	10
24. Bromoform	75-25-2	10	10
25. 4-Methyl-2-pentanone	108-10-1	10	10
26. 2-Hexanone	591-78-6	10	10
27. Tetrachloroethene	127-18-4	10	10
28. Toluene	108-88-3	10	10
29. 1,1,2,2-Tetrachloroethane	79-34-5	10	10
30. Chlorobenzene	108-90-7	10	10
31. Ethyl Benzene	100-41-4	10	10
32. Styrene	100-42-5	10	10
33. Xylenes (Total)	1330-20-7	10	10

Notes: 1. CLP protocols shall be followed exactly as described in the STATEMENT OF WORK FOR ORGANICS ANALYSES (Multi-media, Multi-concentration): Document number OLM01.0, including Revisions OLM01.1 (December 1990) and OLM01.1.1 (February 1991).

Table G-8
Compound List and Reporting Limits for Volatile Organics by GC/MS
(524.2, EPA, Rev. 3.0, August 1992)

Volatiles	CAS Number	Method Detection Limit Water (µg/L)
1. Benzene	71-43-2	0.08
2. Bromobenzene	108-86-1	0.06
3. Bromochloromethane	74-97-5	0.08
4. Bromodichloromethane	75-27-4	0.16
5. Bromoform	75-25-2	0.24
6. Bromomethane	74-83-9	0.22
7. *n*-Butylbenzene	104-51-8	0.22
8. *sec*-Butylbenzene	135-98-8	0.26
9. *tert*-Butylbenzene	98-06-6	0.28
10. Carbon Tetrachloride	56-23-5	0.42
11. Chlorobenzene	108-90-7	0.08
12. Chloroethane	75-00-3	0.20
13. Chloroform	67-66-3	0.06
14. Chloromethane	74-87-3	0.26
15. 2-Chlorotoluene	95-49-8	0.08
16. 4-Chlorotoluene	106-43-4	0.12
17. Dibromochloromethane	124-48-1	0.10
18. 1,2-Dibromo-3-chloropropane	96-12-8	0.52
19. 1,2-Dibromoethane	106-93-4	0.12
20. Dibromomethane	74-95-3	0.48
21. 1,2-Dichlorobenzene	95-50-1	0.06
22. 1,3-Dichlorobenzene	541-73-1	0.24
23. 1,4-Dichlorobenzene	106-46-7	0.06
24. Dichlorodifluoromethane	75-71-8	0.20
25. 1,1-Dichloroethane	75-34-3	0.08
26. 1,2-Dichloroethane	107-06-2	0.12
27. 1,1-Dichloroethene	75-35-4	0.24
28. *cis*-1,2-Dichloroethene	156-59-2	0.24
29. *trans*-1,2-Dichloroethene	156-60-5	0.12
30. 1,2-Dichloropropane	78-87-5	0.08
31. 1,3-Dichloropropane	142-28-9	0.08
32. 2,2-Dichloropropane	594-20-7	0.70
33. 1,1-Dichloropropene	563-58-6	0.20
34. *cis*-1,3-Dichloropropene	10061-01-5	-
35. *trans*-1,3-Dichloropropene	10061-02-6	-
36. Ethylbenzene	100-41-4	0.12
37. Hexachlorobutadiene	87-68-3	0.22
38. Isopropylbenzene	98-82-8	0.30
39. 4-Isopropyltoluene	99-87-6	0.24
40. Methylene chloride	75-09-2	0.06
41. Naphthalene	91-20-3	0.08
42. *n*-Propylbenzene	103-65-1	0.08
43. Styrene	100-42-5	0.08
44. 1,1,1,2-Tetrachloroethane	630-20-6	0.10
45. 1,1,2,2-Tetrachloroethane	79-34-5	0.08
46. Tetrachloroethene	127-18-4	0.28
47. Toluene	108-88-3	0.22
48. 1,2,3-Trichlorobenzene	87-61-6	0.06
49. 1,2,4-Trichlorobenzene	120-82-1	0.08

(Continued)

Notes: 1. Other requirements:
a. Reporting will include a computer search with identification and quantitation of the ten highest non-targeted peaks.
b. Holding times before analysis: 14 days from sample collection in the field if preserved; 24 hours if not preserved.
c. Sample preservation requirements: pH < 2 with HCl, chilled to 4°C, no headspace. Chemical preservation will be checked at time of sample analysis.

Table G-8 (Concluded)

Volatiles	CAS Number	Method Detection Limit Water (µg/L)
50. 1,1,1-Trichloroethane	71-55-6	0.16
51. 1,1,2-Trichloroethane	79-00-5	0.20
52. Trichloroethene	79-01-6	0.38
53. Trichlorofluoromethane	75-69-4	0.16
54. 1,2,3-Trichloropropane	96-18-4	0.64
55. 1,2,4-Trimethylbenzene	95-63-6	0.26
56. 1,3,5-Trimethylbenzene	108-67-8	0.10
57. Vinyl chloride	75-01-4	0.34
58. *o*-Xylene	95-47-6	0.22
59. *m*-Xylene	108-38-3	0.10
60. *p*-Xylene	106-42-3	0.26

precision and accuracy established at acceptable levels for replicate analysis of spiked reagent water samples. The terms used for these spiked samples are QC reference sample, and laboratory fortified blank (LFB), respectively. CLP requires only that background levels meet the criteria noted within the method. All criteria noted must be met prior to the analysis of any field samples.

(7) GC/MS VOA analysis QC requirements. Once an acceptable calibration is established or confirmed, and the other items outlined have been achieved, the analytical system and instrument have proven to be in control and analysis of field samples may commence. The acceptability of those eventual sample results depends on whether internal QC compounds (surrogates, internal standards) criteria and external batch QC sample requirements (MS, MSD, LCS, MB) of precision and accuracy meet method specifications.

(a) Individual sample QC. Every sample, including blanks, standards, sample, matrix duplicate, matrix spike, matrix spike duplicate, etc. must include the addition of compounds (internal standards and surrogate standards) at a known concentration, prior to analysis to monitor responses, retention times, and percent recoveries. Internal standards are also used as the basis of target compound quantitation.

(b) Batch QC sample analysis. Batch QC samples include method blanks, LFBs, duplicates, MSs, and MSDs. Reference Appendix J for definitions of these QC samples. Analysis of these samples provides insight into the precision and accuracy of the analytical run and of performance in association with the matrix under investigation. Required frequency and acceptance criteria are presented in Table G-9.

(8) Corrective action QC sample. For method 8260 the analysis of a QC Reference Standard may be required in the event the criteria established in paragraphs 3*g*(1) or 3*g*(2) fail. The QC Reference Standard is a spiked blank sample prepared by the analyst (preferably from an outside source) which combines a portion of all of the elements being analyzed for calculation of precision and accuracy to verify that the analytical run is being performed in an "in control" mode of operation. The analysis of this standard may be required quarterly, or in response to batch QC criteria failure as noted within the method.

d. Outline for reporting requirements. As noted in paragraph 3.0, numerous items must be checked against method-specific criteria in order to determine the acceptability of the volatile organics data and the analytical run as a whole. In order that USACE may confirm the quality of the data received, much of this information must be relayed along with the sample results in order to complete an independent review or validation of the data. These data-reporting package requirements must be clearly defined within the SAP. Two data reporting formats may be anticipated for use with USACE projects: (1) a data package that is forecast to be submitted to the USACE Quality Assurance Laboratory for CQAR generation, and (2) a package that can be fully validated (e.g., similar to CLP). The contract laboratory is required to submit the required data package to appropriate personnel, as identified within the SAP, for review or validation, respectively. The following outline addresses only (1) the submittal required by the USACE quality assurance laboratory in order that the project CQAR be generated. Refer to the USACE Functional Guidelines for Data Validation for the requirements of the (2) data package that can be fully validated. Reference paragraph 11*d* of

Table G-9
Requirements for Volatile Organic Compound Analysis by GC/MS

Sample/Procedure	Minimum Criteria[1] SW-846	CLP[2]	EPA-600
GC/MS Initial Calibration for Target Compounds:			
• Trap conditioning at 180°C with backflushing	(daily) 10 min	(daily) 10 min	(daily) 10 min
• Tune GC/MS system with suitable calibrant	✓	✓	✓
• Verify calibration of mass abundances with BFB meets criteria noted	(Table 4)	(Table 1)	(Table 3)
• Purge medium standard to verify system sensitivity:	-	-	(Figure 3)
• Purge prepared calibration standards	(5 stds) (¶5.12)	(5 stds) (¶ 5,5)	(3 to 5 stds) (¶ 7.8)
• Tabulate area response of characteristic ions for all compounds and internal standard(s) (IS) for each std. Calculate (relative) response factor (RF/RRF) of compounds using assoc. ISs	✓ (58 cmpds) (¶ 1.1) (4 IS) (Table 6)	✓ (33 cmpds) (Ex. C) (3 IS) (Table 5)	✓ (60 cmpds) (¶ 1.1) (1 IS) (¶ 7.5)
• Calculate mean RF/RRF for all compounds from all standards run	✓	✓	✓
• Verify minimum RF/RRF criteria met for noted compounds	(5 SPCCs) (¶ 7.3.7)	(24 cmpds/12 cmpds) (Table 2/¶ 7.4.6)	-
• Calculate relative std deviation (%RSD) for all compounds from each mean	✓	✓	✓
Verify %RSD does not exceed criteria for noted compounds	(6 CCCs) (¶ 7.3.8) (< 30%)	(24 cmpds) (Table 2)	(all cmpds) (¶ 9.2.6.1) (< 20%)
GC/MS Continuing Calibration for Target Compounds			
• Verify tune & initial calibration curve of GC/MS daily or as noted	every 12 hr	every 12 hr	beg. of each 8-hr shift
• Verify that calibration of mass abundances with BFB meets criteria noted	(Table 4)	(Table 1)	(Table 3)
• Purge medium standard (a.k.a CCS, CCC) to verify criteria are met as noted compared with last initial calibration	(5 SPCCs-) (¶ 7.4.3) (6 CCCs) (¶ 7.4.4)	(¶ 7.4.5) (¶ 7.4.6) (¶ 7.4.7) (Table 2)	(Figure 3) (¶ 9.2.4) (¶ 9.3.4) (¶ 9.3.5)

(Continued)

Notes:
[1] Full method citations given in paragraph 1.0 of this instruction.
[2] Refer to Exhibit D of CLP - VOA method, unless otherwise stated.
- Not required/criteria not specified.
✓ Required within method as noted with no further clarification.
CCS, CCC = Calibration check standards.
SPCC = System performance check standard.

Table G-9 (Concluded)

Sample/Procedure	Minimum Criteria[1] SW-846	CLP[2]	EPA-600
Preliminary GC/MS Method Quality Control (QC) Procedures			
• Blanks (RB, MB, LRB) must show background levels meet criteria noted	<MDL, <5% regulatory level; or <5% sample concentration.	(Ex. E) (¶ 5.2)	<MDL
• Analyze the noted number of replicates of QC ref. samples (a.k.a. Laboratory Fortified Blank (LFB)) to establish acceptable results for precision and accuracy as required by each method	(4 rep.) (¶ 8.3) (Table 7) (Table 8)		(5 - 7 rep.) (¶ 10.3) (%R = 80-120%) (RSD < 20%)
GC/MS VOA Analysis QC Requirements Batch QC Sample Analysis (Required Every 20 Similar Matrix Samples)			
• Verify that IS(s) response and retention times do not change more than method criteria allow compared to most recent calibration std.	(4 cmpds) (¶ 5.10) (¶ 7.4.5)	(3 cmpds) (¶ 5.4.3) (¶ 10.2)	(1 cmpd) (¶ 7.5) (¶ 9.3.4) (¶ 10.4)
• Verify that surrogate cmpd (a.k.a. system monitoring cmpds) responses have not changed more than criteria, and that the recoveries exhibited are within the method limits	(3 cmpds) (¶ 5.9) (Table 9)	(3 cmpds) (¶ 5.4.4) (Table 6)	(2 cmpds) (¶ 7.5.1) (¶ 9.3.4) (¶ 10.4) (Table 6)
• Blanks (RB, MB, LRB) must show that background levels meet criteria noted	<DL or <5% of cmpd ARAR or <5% of sample concentration found	(Ex. E) (5.2)	<MDL
LFB must show that accuracy is within established criteria and MDLs are obtainable			(¶10.6) (%R = 80-120%) ✓
• Matrix spike (MS) must be prepared with the corresponding spiking cmpds and meet the method criteria	(5 cmpds) (¶ 5.13) (Table 6)	(5 cmpds) (¶ 5.4.5.1) (Table 7)	-
• MS duplicate (MSD) must be prepared in the same manner as MS and be analyzed to verify precision of instrument/analytical run	(¶ 5.13) (Table 6)	(¶ 5.4.5.2) (Table 7)	-
• Duplicate (DUP)	(Table 6)	-	-
Corrective Action QC Sample (Required if sample (MS, MSD, DUP) criteria fail)			
• QC Reference Standard must be prepared/ analyzed with each compound that failed QC criteria to verify criteria are met within a reagent water matrix and the analysis is in control	(method 8000A) (¶ 8.6) (Table 6)	-	-

Appendix B for specific details on the subject results identified below.

(1) Case narrative.

(2) Sample, matrix spike, and matrix spike duplicate results.

(3) BFB tuning.

(4) Initial and/or continuing calibration check(s).

(5) Method blank.

(6) Surrogate recoveries.

(7) Matrix duplicate.

(8) Matrix spike.

(9) Matrix spike duplicate.

(10) Laboratory control sample/QC reference sample.

(11) Supporting data.

e. Recommended collection volumes for VOA determinations.

Matrix	Prep. Vol./Wt.	Collection Volume/Wt.
Water	5-25 mL(2x)	40 mL
Soils/ Sediment	5 gm (2x)	40 mL

f. Decontamination requirements. The proper decontamination procedure for equipment utilized in conjunction with volatile organic sample acquisition and analysis is as follows:

(1) Remove residuals immediately after use.

(2) Soak with hot tap water to loosen most particulates.

(3) Rinse with hot water to flush particulate matter.

(4) Soak with oxidizing agent to destroy organic compounds.

(5) Rinse with hot water to flush additional particulate matter.

(6) Rinse with distilled (ASTM II) water.

(7) Rinse with methanol to flush off any trace organics and water.

(8) Dry and store.

(9) Prior to use, rinse with same solvent used in the procedure.

Appendix H
Quality Assurance/Quality Control Procedures

H-1. Contractor Chemical Quality Control (CCQC) Three-Phase Control Process

a. Preparatory phase. This is a generic checklist that should be modified to reflect actual conditions anticipated at the site. Items may be added or deleted from the checklist as appropriate for site conditions. A project-specific checklist should be developed and presented in Section 8.0 of the field sampling plan portion of the sampling and analysis plan.

(1) Checklist of field equipment and other materials.

(a) Contract specifications.

(b) Contract plans.

(c) Sampling and analysis plan.

(d) Example tables for recording of all data.

(e) Base maps for documenting sampling locations.

(f) Quality assurance (QA) sample table to match up the quality control (QC) and QA samples (Figure H-1 is an example of the format).

(g) Technical reference books for the identification of chemical hazards.

(h) Hazardous waste manifest forms.

(i) Reference materials for proper completion of manifests.

(j) Field screening instruments.

(k) Calibration gas.

(l) Calibration standards.

(m) Instrument operating manual, with copy provided to the quality assurance personnel as an attachment to the DCQCR, if not already provided in the sampling and analysis plan.

(n) Backup instrument for field screening.

(o) Established procedures for instrument repair.

(p) Standard operating procedures for decontamination.

(q) Decontamination materials including solvents, rinse water, tissue, etc.

(r) Sample collection equipment.

(s) Labels for sample containers.

(t) Examples of completed sample shipping documents, e.g., air bills.

(u) Sample containers of the types to be used for each analysis.

(v) Chain-of-custody forms.

(w) Chain-of-custody seals.

(x) Sample shipping coolers.

(y) Strapping tape.

(z) Sample packing materials, including plastic bags and vermiculite.

(aa) Ice packs to cool sample cooler.

(bb) Sample preservatives, such as acid for metals, etc.

(cc) Laboratory information: name; address; phone number; point of contact; turnaround time for the analyses; and documentation that all labs have been notified that the samples will be shipped and confirmation that the laboratory will accept the samples.

(dd) Copy of a phone log with USACE QA laboratory showing that the government QA samples have been scheduled with the laboratory.

(ee) Copy of ENG Form 4025, which remedial action contractors will use to transmit analytical data.

(2) Checklist of activities.

(a) The CQC representative shall review all pertinent sections of the plans and specifications during the preparatory meeting in order to ensure that all field personnel

Sample Location	Sample Depth	Sample Number (Primary Lab)	QC Sample Number (Primary Lab)	Associated Trip Blank Number (Primary Lab)	Associated Rinsate Blank (Primary Lab)	Sample Number (QA Lab)	Associated Trip Blank Number (QA Lab)	Associated Rinsate Blank (QA Lab)	EPA 8240	EPA 8270	EPA 239.2	EPA 418.1

Note: This table is to be completed in the field based upon the actual samples taken.

Figure H-1. Example sample table

are cognizant of the overall project data quality objectives (DQOs) as well as any specific sampling and analysis requirements. This should include reading the sections aloud, if necessary, to clarify the requirements.

(b) Likewise the sampling and analysis plan should be reviewed in detail.

(c) All instruments should be calibrated during the preparatory inspection meeting using certified calibration standards, gases, etc.

(d) Equipment decontamination procedures will be demonstrated in detail using the proper decontamination solutions in accordance with the sampling and analysis plan.

(e) A full set of sample custody forms will be completed to be used as a guide during sampling. The sample numbering system will be discussed. The laboratory addresses and phone numbers will be recorded on the form. Analytical test methods will be discussed and recorded on the form. Caution should be exercised to assure that the test method is clearly specified. Sample preservation will be recorded on the form. All required data should be documented on this sample form.

(f) The sampling team should demonstrate in detail how each type of sample will be collected, using the intended sample containers, sampling equipment, decontamination procedures, and data reporting requirements.

(g) Laboratory turnaround times shall be established and documented in the minutes of the preparatory meeting. The CQC representative shall present a tracking system to assure that all data are received in a timely manner.

b. Initial phase checklist of activities.

(1) The CQC representative should oversee the sampling activities and review the work for compliance with contract requirements.

(2) Individual sample labels and chain-of-custody forms will be inspected for accuracy, completeness, and consistency.

(3) The packaging and shipping of the samples will also be inspected by the CQC representative.

(4) Initial instrument calibration and ongoing calibrations will be observed, verified, and documented.

(5) Field notes will be inspected to assure that all pertinent data are recorded in accordance with the contract requirements. These notes shall include identification of field control samples (replicate samples, split samples, field blanks, etc.), detailed sketches showing the sample locations, and any other items identified from Instruction F-1 as applicable to the project. These sample locations should be recorded daily on the as-built drawings.

(6) The sampling team leader should complete the table which matches up primary and QA samples, at the conclusion of each day of sampling and attach a copy of the DCQCR.

c. Follow-up phase.

The CQC representative is responsible for continued daily contract compliance until completion of the particular feature of work.

H-2. Field and Laboratory Control Samples

a. Purpose. The purpose of this instruction is to describe standard control samples included within a project data collection program to support the data quality objectives. The samples described include field control and/or laboratory QC samples used to assess sources of error at each stage of the sampling and analytical process. The entire sequence of sample gathering, preservation, storage, and shipment has unique errors associated with it, as do the events which occur in the analytical laboratory. To minimize or consider the impact these errors have on the resulting data, a combination of unique field and laboratory QA/QC protocols and control samples are incorporated into the project data collection program based upon project DQOs. U.S. Army Corps of Engineers (USACE) policy on QA/QC implementation and frequency requirements are specifically addressed in ER 1110-1-263.

b. Field control samples. Principal elements of the sampling and field QA/QC strategy include 1) developing a sound sampling approach based upon the intended use of the data; 2) use of sampling methodologies which allow the collection of representative samples based upon data needs; 3) use of sampling devices that minimize the disturbance or alteration to the media's chemical composition; 4) employing decontamination procedures which reduce cross-contamination potential between sampling points; and 5) the use of proper sample containers and preservation techniques which maximize the integrity of the samples. The applicability and appropriateness of the field sampling protocol can be verified by the inclusion of

a program of scheduled field control samples, such as field replicates (duplicates, splits, field spikes), field blanks (rinsate (equipment), bottle, and trip), and background (upgradient) samples. All field control samples shall be handled exactly as the environmental samples. The identity of all field control samples collected must be held blind to the laboratory until the data are reported. Further discussion on sample number assignment is contained in Instruction F-1 (Appendix F).

(1) Field replicates. Field replicates are samples taken in quantity at a particular location or time in order to assess error associated with sample heterogeneity, sampling methodology applicability, and sample handling techniques. These replicates may be used for various purposes depending upon the intended use of the data or eventual analysis. The different types of replicates include field duplicates/triplicates, field splits, or field spikes. According to USACE nomenclature, field QC duplicate/triplicate samples are (collocated or homogenized) replicates of field samples which are sent blindly to the contractor's lab to assess the field sampling precision through a review of the final results. If sufficient field replicates (minimum of eight) are taken, statistics may then be used to identify the general heterogeneity of the media population being assessed. Similarly, field QA split samples are (collocated or homogenized) replicates of field samples, except these are sent to the government QA laboratory for analysis. These field split samples have been used by USACE for early detection of problems with contractor's field sampling, documentation, packaging, and/or shipping errors. In addition, this referee laboratory analysis offers a source of data which may provide special attention to the achievement of lower detection limits, allow the performance of supplementary cleanup procedures to avoid matrix interferences, or may help identify an analyte as a laboratory contaminant. These split samples are especially important to the generation of the QA/QC tables included within the USACE Contractor's Quality Assurance Report (CQAR). Field spikes are not commonly used. These samples involve the utilization of a sample replicate to which a known quantity of analyte is added in the field and sent blind to the laboratory. This type of sample is used to evaluate the laboratory's accuracy by comparing the recovery of analyte reported to the amount added. In addition, it may be used to monitor the Contractor's implementation of sample handling and shipping procedures. Care should be taken when preparing this type of sample, because of the field exposure and cross-contamination potential involved with a contaminant source being used in the field. Finally, it should be noted that the methodology used for field replicate sample acquisition differs (collocated or homogenized), depending upon the media being sampled and the requirements of subsequent analysis.

(a) Collocated (grab) replicates. Aqueous media and samples which require grab techniques (e.g., volatile organics (VOA)) are field replicates obtained from multiple grab samples, collected separately and placed directly into sample containers. Theoretically, each grab sample equally represents the medium at a given time and location.

(b) Homogenized field replicates. Field replicates of non-aqueous matrices whose subsequent analysis allows prior homogenization of the media are obtained from one location in sufficient volume to fill all sample containers. The media is then homogenized, divided into two or more equal parts, and aliquots of each part are used to fill each sample container. Refer to Instruction E-2 in Appendix E for details on this sampling technique.

(2) Blanks. Whenever the possibility exists for contributing extraneous material into the sample collection, shipment, or analysis, a blank sample should be used to assess the magnitude of this contribution. Blank samples associated with the field sampling effort include field blanks, rinsate (equipment) blanks, trip blanks, and temperature blanks.

(a) Field (bottle) blanks. Field blanks are not commonly used on USACE projects, however, they may be required based upon customer, or regulatory authority preference. Field blanks are analyte-free (deionized) water or certified clean sand which is transferred to the appropriate sample containers in the field, and submitted for analysis. These samples are used to assess the potential incidental contamination due to the field operations (exposure to air) and/or contamination due to the sample container.

(b) Rinsate (equipment) blanks. Rinsate blanks are samples of analyte-free (deionized) water which are rinsed over decontaminated sampling equipment, collected, and submitted for analysis. These samples are used to assess cross-contamination from the sampling equipment, in addition to incidental contamination and/or the sample container.

(c) Trip blanks. Trip blanks are samples of organic-free (deionized) water that are prepared in the laboratory, shipped onsite with the other sample containers, and then returned to the laboratory unopened in each shipping container that contains aqueous VOA samples. Because trip blanks pertain only to VOA samples, the containers

must have been prepared in the laboratory with no headspace. Although not commonly used for USACE projects, trip blanks may also consist of a certified clean sand, to assess shipments of solid matrix VOA samples. Trip blanks are used to evaluate the potential cross-contamination that may occur during shipment.

(d) Temperature blanks. A temperature blank is a container (e.g., 40 mL) of water packaged along with field samples in the shipping cooler that will represent the temperature of the incoming cooler upon receipt at the laboratory. Use of these samples within a shipping container enables the receiving laboratory to assess the temperature of shipment without disturbing any project field samples.

(3) Background (upgradient) samples. Background, upgradient, or upwind samples are media samples similar to the sample under investigation, but outside the presumed area of contamination. The sample locations or time should be near that of the field samples but will vary depending upon media and site conditions. These samples are taken to measure the concentration of analytes considered naturally occurring, potentially due to another contaminant source, or due to the media used in sample acquisition. Background samples of each unique matrix should be acquired to evaluate the presence of analytes within the field samples. Background samples are especially recommended for complex matrices due to the interferences which may occur during analysis. Another method of collecting background samples involves taking samples in conjunction with another media (e.g., wipe samples). This would entail sending all of the media involved with the sample methodology without exposure to the contaminant under investigation (e.g., filter/solvent media). Analysis of these samples allows an evaluation of the contribution due to the media used in sample acquisition.

c. Laboratory QA/QC procedures. Laboratory QA/QC procedures are implemented in order to prevent, detect, and correct errors in the analytical process. In order to ensure that quality data are continuously produced during all analyses, and to allow eventual compliance review, systematic checks are performed to show that test results remain reproducible and that the analytical method is actually measuring the quantity of target analytes in each sample without unacceptable bias. The reliability and credibility of analytical laboratory results are typically corroborated by the inclusion of a program of scheduled analyses of replicates, standards, reference solutions, surrogates, and/or spiked samples. It should be emphasized here that additional volumes and/or samples are required when matrix spike/matrix spike duplicate analysis is required for the project in order to assess the appropriateness and accuracy of the laboratory's analytical method with regard to the matrix under investigation. Individual analytical methods should be reviewed for details on the scheduled QC procedures required during analysis. Additional information on the laboratory QC samples required may be referenced from Appendix B, "Chemical Analysis Requirements," and analytical instructions presented within Appendix G.

Appendix I
Preservatives, Holding Times and Sample Containers

Table I-1
Preservatives, Holding Times and Sample Containers

	Preservative[7]		Holding Time		Containers[5]	
Parameter	Liquid	Solid	Liquid	Solid	Liquid	Solid
VOLATILE ORGANICS	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present) No headspace, HCl to pH <2	Cool 4°C, No headspace	14 days	14 days	2-40 mL glass vial, PTFE septa cap	2-40 mL glass vial or 2 - 4 oz glass, PTFE septa cap
Acrolein & Acrylonitrile	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present) HCl to 4 < pH < 5, No Headspace	Cool 4°C, No headspace	14 days	14 days	2-40 mL glass vial	4 oz cwm[4] PTFE septa cap
Purgeable Aromatic Hydrocarbons	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present) HCl to pH <2	Cool 4°C, No headspace	14 days	14 days	2-40 mL glass vial, PTFE septa cap	4 oz cwm[4], PTFE septa cap
Purgeable Halocarbons	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present) No Headspace	Cool 4°C, No headspace	14 days	14 days	2-40 mL glass vial, PTFE septa cap	4 oz cwm[4], PTFE septa cap
SEMIVOLATILE ORGANICS	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present)	Cool 4°C	7d/40d[2]	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[10]
Benzidines	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present)	Cool 4°C	7d/40d[2]	14d/40d[9]	1 L A.G.[6]	8 oz cwm[4]
Chlorinated Herbicides	Cool 4°C	Cool 4°C	7d/40d[2]	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[4]
Chlorinated Hydrocarbons	Cool 4°C	Cool 4°C	7d/40d[2]	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[4]
Chlorinated Pesticides	Cool 4°C, H_2SO_4 or NaOH to 5 < pH < 9	Cool 4°C	7d/40d[2]	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[10]
Dioxins & Furans	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present)	Cool 4°C	30d/45d[12]	30d/45d[12]	2 - 1 L A.G.[6]	8 oz cwm[4]
Haloethers	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present)	Cool 4°C	7d/40d[2]	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[4]
Nitroaromatics & Isophorone	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present)	Cool 4°C	7d/40d[2]	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[4]
Nitrosamines	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present)	Cool 4°C	7d/40d[2]	14d/40d[9]	1 L A.G.[6]	8 oz cwm[4]
PCBs/Pesticides	Cool 4°C	Cool 4°C	7d/40d[2]	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[10]
Phenolics	Cool 4°C, H_2SO_4 to pH < 2	Cool 4°C	28 days	28 days	1 L B.R.[8]	8 oz cwm[4]

(Sheet 1 of 4)

Table I-1 (Continued)

	Preservative[7]		Holding Time		Containers[5]	
Parameter	Liquid	Solid	Liquid	Solid	Liquid	Solid
Phenols	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present)	Cool 4°C	7d/40d[2]	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[4]
Phthalate Esters	Cool 4°C	Cool 4°C	7d/40d[2]	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[4]
Polynuclear Aromatic Hydrocarbons	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present)	Cool 4°C	7d/40d[2]	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[4]
Metals (Except Chromium(VI) & Hg)	Cool 4°C, HNO_3 to pH <2	Cool 4°C	6 months	6 months	1 L HDPE[3]	8 oz cwm[11]
TRPH	Cool 4°C, H_2SO_4 to pH < 2	Cool 4°C	28 days	28 days	2 - 1 L glass	8 oz cwm[11]
Chromium(VI)	Cool 4°C	Cool 4°C	24 hours	24 hours	250 mL HDPE[3]	8 oz cwm[4]
Cyanide (Total & Amenable)	Cool 4°C, NaOH to pH > 12, (0.6g Asbc Acid if residual Cl is present)	Cool 4°C	14 days	14 days	1 L HDPE[3]	8 oz cwm[11]
Mercury	Cool 4°C, HNO_3 to pH < 2	Cool 4°C	28 days	28 days	250 mL HDPE[3] or glass	8 oz cwm[4]
MISCELLANEOUS						
Acidity	Cool 4°C	N/A	48 hours	N/A	250 mL HDPE[3]	N/A
Alkalinity	Cool 4°C	N/A	48 hours	N/A	250 mL HDPE[3]	N/A
Ammonia	Cool 4°C, H_2SO_4 to pH < 2	N/A	14 days	N/A	1 L HDPE[3]	N/A
Biochemical Oxygen Demand (BOD)	Cool 4°C, H_2SO_4 to pH < 2	N/A	48 hours	N/A	2 L HDPE[3]	N/A
Biochemical Oxygen Demand (Carbonaceous)	Cool 4°C	N/A	48 hours	N/A	2 L HDPE[3]	N/A
Bromide	None required	N/A	28 days	N/A	250 mL HDPE[3]	N/A
Chemical Oxygen Demand[1]	Cool 4°C, H_2SO_4 to pH< 2	N/A	28 days	N/A	125 mL HDPE[3]	N/A
Chloride	None required	None required	28 days	28 days	125 mL HDPE[3]	4 oz cwm[4]
Chlorine (Total Residual)	None required	N/A	A.S.A.P.	N/A	500 mL HDPE[3]	N/A
Coliform, Fecal & Total	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present)	Cool 4°C	6 hours	6 hours	120 mL HDPE[3]	4 oz cwm[4]
Color	Cool 4°C	N/A	48 hours	N/A	125 mL HDPE[3]	N/A

(Sheet 2 of 4)

Table I-1 (Continued)

Parameter	Preservative[7]		Holding Time		Containers[5]	
	Liquid	Solid	Liquid	Solid	Liquid	Solid
Dissolved Oxygen, Probe	None required	N/A	0.5 hour	N/A	300 mL BOD btl.	N/A
Dissolved Oxygen, Winkler Method	Fix on site/store dark	N/A	8 hours	N/A	300 mL BOD btl.	N/A
Explosives	Cool 4°C	Cool 4°C	7d/40d	14d/40d[9]	2 - 1 L A.G.[6]	8 oz cwm[4]
Fecal Streptococci	Cool 4°C, (.008% $Na_2S_2O_3$ if residual Cl present)	N/A	6 hours	N/A	250 mL HDPE[3]	N/A
Fluoride	None required	N/A	28 days	N/A	500 mL HDPE[3]	N/A
Hardness	HNO_3 or H_2SO_4 to pH <2	N/A	6 months	N/A	250 mL HDPE[3]	N/A
Hydrogen Ion (pH)	None required	Cool 4°C	A.S.A.P.	A.S.A.P.	60 mL HDPE	4 oz cwm
Kjeldahl and Organic Nitrogen	Cool 4°C, H_2SO_4 to pH < 2	N/A	28 days	N/A	1 L HDPE[3]	N/A
Nitrate	Cool 4°C	Cool 4°C	48 hours	48 hours	250 mL HDPE[3]	8 oz cwm[4]
Nitrate-Nitrite	Cool 4°C, H_2SO_4 to pH < 2	Cool 4°C	28 days	28 days	250 mL HDPE[3]	8 oz cwm[4]
Nitrite	Cool 4°C	N/A	48 hours	N/A	125 mL HDPE[3]	N/A
Oil & Grease	Cool 4°C, H_2SO_4 to pH < 2	Cool 4°C	28 days	28 days	2 - 1 L glass	8 oz cwm[4]
Organic Carbon	Cool 4°C, HCl or H_2SO_4 to pH <2	Cool 4°C	28 days	28 days	125 mL HDPE[3]	4 oz cwm[4]
Orthophosphate	Filter immediately Cool 4°C	N/A	48 hours	N/A	125 mL HDPE[3]	N/A
Phosphorus (Elemental)	Cool 4°C	N/A	48 hours	N/A	1 L B.R.[8]	N/A
Phosphorus (Total)	Cool 4°C, H_2SO_4 to pH < 2	N/A	28 days	N/A	125 mL HDPE[3]	N/A
Radiological Test, Gross Alpha	HNO_3 to pH < 2	Cool 4°C	6 months	6 months	2 L HDPE[3]	8 oz HDPE[3]
Radiological Test, Gross Beta	HNO_3 to pH < 2	Cool 4°C	6 months	6 months	2 L HDPE[3]	8 oz HDPE[3]
Radiological Radium (Total)	HNO_3 to pH < 2	Cool 4°C	6 months	6 months	2 L HDPE[3]	8 oz HDPE[3]
Residue (Filterable)	Cool 4°C	N/A	7 days	N/A	250 mL HDPE[3]	N/A
Residue (Non-Filterable)	Cool 4°C	N/A	7 days	N/A	250 mL HDPE[3]	N/A
Residue (Settleable)	Cool 4°C	N/A	48 hours	N/A	Imhoff cone	N/A
Residue (Total)	Cool 4°C	N/A	7 days	N/A	250 mL HDPE[3]	N/A
Residue (Volatile)	Cool 4°C	N/A	7 days	N/A	250 mL HDPE[3]	N/A

Table I-1 (Concluded)

Parameter	Preservative[7]		Holding Time		Containers[5]	
	Liquid	Solid	Liquid	Solid	Liquid	Solid
Silica	Cool 4°C	N/A	28 days	N/A	125 mL HDPE[3]	N/A
Specific Conductance	Cool 4°C	N/A	28 days	N/A	250 mL HDPE[3]	N/A
Sulfate	Cool 4°C	Cool 4°C	28 days	28 days	125 mL HDPE[3]	4 oz cwm[4]
Sulfide	Cool 4°C, 4 mL ZnAc plus NaOH to pH > 9	Cool 4°C	7 days	7 days	1 L HDPE[3]	8 oz cwm[4]
Sulfite	Cool 4°C	N/A	A.S.A.P.	N/A	125 mL HDPE[3]	N/A
Surfactant	Cool 4°C	N/A	48 hours	N/A	500 mL HDPE[3]	N/A
TCLP Extractable Fraction	Cool 4°C	Cool 4°C	14 days/ N/A/ 14 days[13]	14 days/ N/A/ 14 days[13]	3 - 1 L A.G.[6]	16 oz cwm[4]
TCLP Volatile Fraction	Cool 4°C, No headspace	Cool 4°C, No headspace	14 days/ 7 days/ 40 days[13]	14 days/ 7 days/ 40 days[13]	500 mL glass PTFE lined septa	4 oz glass with PTFE-lined septum
TCLP Inorganic Fraction (Hg)	Cool 4°C	Cool 4°C	28 days/ N/A 28 days[13]	28 days/ N/A 28 days[13]	1 L HDPE[3]	16 oz cwm[4]
TCLP Inorganic Fraction (all other metals)	Cool 4°C	Cool 4°C	180 days/ N/A 180 days[13]	180 days/ N/A 180 days[13]		
Temperature	None required	N/A	A.S.A.P.	N/A	2 L HDPE[3]	N/A
Total Organic Halogens (TOX)	Cool 4°C, H_2SO_4 to pH < 2	28 days	28 days	28 days	16 oz B.R.[8]	4 oz cwm[4]
Turbidity	Cool 4°C	N/A	48 hours	N/A	250 mL HDPE[3]	N/A

(Sheet 4 of 4)

NOTES:

1 - Organic carbon content must be greater than 50 mg/L for valid results.
2 - 7 days until extraction/analyzed within 40 days of extraction.
3 - HDPE (high-density polyethylene bottles).
4 - CWM (clear wide mouth) glass jars.
5 - All containers must have Teflon-lined seals (Teflon-lined septa for VOA vials).
6 - Amber glass jug.
7 - High concentration samples require cooling to only 4°C.
8 - B.R. (Boston round)
9 - 14 days until extraction/analyzed within 40 days of extraction.
10 - Semivolatiles, PCBs/pesticides may be collected in the same container.
11 - Metals, TRPH, and cyanide may be collected in the same container.
12 - Holding time for TRPH is 28 days.
13 - Sample containers for TPRH are 2 x 1 L glass bottles.
NA - Not available.

Appendix J
Acronyms and Definitions

Acronyms

A-E	Architect - Engineer
AA	Atomic absorption
ACE	U.S. Army Corps of Engineers (EPA terminology)
ACE	Assistant Chief of Engineers
AF	Air Force
AFB	Air Force Base
AL	Action level
ALARA	As low as reasonably achievable
amu	Atomic mass units
ANSI	American National Standards Institute
AOAC	Association of Official Analytical Chemists
AOC	Area of concern
ARAR	Applicable, or relevant and appropriate requirements
AST	Aboveground storage tank
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AVO	Aromatic volatile organics
AWQC	Ambient water quality criteria
BACT	Best available control technology
BAT	Best available technology
BDAT	Best demonstrated available technology
BFB	Bromofluorobenzene
BNA	Base, neutral, acids (semivolatile organics)
BNA	Bureau of National Affairs
BOD	Biological oxygen demand
BOE	Bureau of Explosives
BTEX	Benzene, toluene, ethylbenzene, and xylene
CA	Corrective action
CAA	Clean Air Act
CAAA	Clean Air Act amendments
CAMU	Corrective Action Management Unit
CCC	Calibration Check Standards
CCQC	Contractor Chemical Quality Control
CCV	Continuing Calibration Verification
CD	Consent decree
CDAP	Chemical data acquisition plan
CDC	Centers for Disease Control
CDQM	Chemical data quality management
CEGS	U.S. Army Corps of Engineers Guide Specification
CERCLA	Comprehensive Environmental Response, Compensation, Liability Act
CERCLIS	CERCLA Information System
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
CGM	Combustible Gas Meter
CHMM	Certified Hazardous Material Manager
CLP	Contract Laboratory Program
CMA	Chemical Manufacturers Association
CME	Central mine equipment sampler
CMI	Corrective measures implementation
CMS	Corrective measures studies
CNAEL	Committee on National Accreditation of Environmental Laboratories
CO	Contracting Officer
COC	Chain of custody
COD	Chemical oxygen demand
COE	U.S. Army Corps of Engineers
COLIWASA	Composite liquid waste sampler
CQAR	Chemical quality assurance report
CQC	Contractor quality control
CRP	Community Relations Plan
CRDL	Contractor-required detection limit
CRQL	Contractor-required quantitation limit
CRT	Cathode ray tube
CSR	Constant sampling rate
CV (COV)	Coefficient of variation
CWA	Clean Water Act
DCQAP	Data Collection Quality Assurance Plan
DDT	Dichlorodiphenyltrichloroethane
DEIS	Draft Environmental Impact Statement
DERA	Defense Environmental Restoration Account
DERP	Defense Environmental Restoration Program
DFTPP	Decafluorotriphenylphosphate
DMP	Data management plan
DNAPL	Dense non-aqueous phase liquid
DO	Dissolved oxygen
DOD	Department of Defense
DOI	Department of Interior
DOE	Department of Energy
DOT	Department of Transportation
DPM	Defense priority model
DQOs	Data quality objectives
DRE	Destruction and removal efficiency

DWPL	Drinking Water Priority List
EA	Endangerment assessment
ECD	Electron capture detector
EDF	Environmental Defense Fund
EE/CA	Engineering evaluation/cost analysis
EHS	Extremely hazardous substances
EHW	Extremely hazardous waste
EIA	Enzyme immunoassay
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ELCD	Electrolytic conductivity detector
EM	Engineer manual
EO	Executive Order
EO	Explosive ordnance
EOD	Explosive ordnance disposal
EP Tox	Extraction procedure toxicity
EPA	U.S. Environmental Protection Agency
EQL	Estimated quantitation limit
ER	Engineering regulation
ETL	Engineer technical letter
eV	Electron volt
FDE	Findings and determination of eligibility
FEMA	Federal Emergency Management Agency
FFA	Federal facility agreement
FFP	Firm fixed price
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FID	Flame ionization detector
FLAA	Flame atomic absorption
FR	Federal Register
FS	Feasibility study
FSP	Field sampling plan
FTIR	Fourier transform infrared (spectroscopy)
FUDS	Formerly used defense site
FY	Fiscal year
GAC	Granulated activated carbon
GALP	Good automated laboratory practices
GAO	Government Accounting Office
GC	Gas chromatograph or gas chromatography
GC/MS	Gas chromatograph/mass spectrometer
GFAA	Graphite furnace atomic absorption
GLP	Good laboratory practices
GPC	Gel permeation column (chromatography)
HAP	Hazardous air pollutant
HAZCAT	Hazardous characterization (testing)
HAZMAT	Hazardous materials
HAZWRAP	Hazardous Waste Remedial Program
HDPE	High density polyethylene
HE	High explosive
HPLC	High performance liquid chromatography
HRS	Hazard Ranking System
HSL	Hazardous Substance List (TAL + TCL)
HSWA	Hazardous and solid waste amendments
HRGC	High resolution gas chromatography
HTRW	Hazardous, toxic, and radioactive waste
HTRW-MCX	Hazardous, toxic, and radioactive waste - mandatory center of expertise
HVO	Halogenated volatile organics
IAG	Interagency agreement
IC	Ion chromatography
ICAP	Inductively coupled argon plasma emission spectroscopy
ICP	Inductively coupled plasma
ICS	Instrument check standard (or sample)
IDL	Instrument detection limit
IDW	Investigation-derived waste
IEC	Interelement correction standard
IPR	Inventory project report
IR	Infrared radiation
IRP	Installation Restoration Program
IRIS	Integrated Risk Information System
ISE	Ion selective electrode
ISO	International Standards Organization
ITA	Innovative technology advocate
IUPAC	International Union of Pure and Applied Chemistry
LAER	Lowest achievable emissions rate
LC	Liquid chromatography
LFG	Landfill gas
LCS	Laboratory control sample
LDR	Land disposal restrictions (LANDBAN)
LIMS	Laboratory Information Management System
LLE	Liquid-liquid extraction
LLW	Low level waste (radioactive)
LOD	Limit of detection
LOQ	Limit of quantitation
LQMP	Laboratory Quality Management Plan
LSE	Liquid-solid extraction
LUST	Leaking underground storage tank
MB	Method blank

MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
MCS	Media cleanup standards
MCX	Mandatory Center of Expertise
MDL	Method detection limit
MEK	Methyl Ethyl Ketone (2-butanone)
MFR	Memorandum for Record
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MS	Mass spectrometer
MS	Matrix spike
MSA	Method of standard additions
MSD	Matrix spike duplicate
MSDS	Material safety data sheet
MSL	Mean sea level
MSW	Municipal solid waste
MWIP	Monitoring well installation plan
NAAQS	National ambient air quality standards
NBS	National Bureau of Standards
NCP	National contingency plan
NEIC	National enforcement investigations center
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology (formerly NBS)
NOI	Notice of intent
NPD	Nitrogen - phosphorus detector
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Pollution Drinking Water Regulation
NPL	National Priorities List
NPS	Non-point source
NRC	Nuclear Regulatory Commission
NRC	National Response Center
O & M	Operations and maintenance
OEW	Ordnance and explosive waste
OMSQA	Office of Monitoring Systems and Quality Assurance
OSC	On-scene coordinator
OSWER	Office of Solid Waste and Emergency Response
OTA	Office of Technology and Assessment
OVA	Organic vapor analyzer
PA	Performance audit
PA/SI	Preliminary assessment/site inspection
PAC	Powdered activated carbon
PAH	Polynuclear aromatic hydrocarbon
PARCC	Precision, accuracy, representativeness, comparability, and completeness
PAT	Proficiency analytical testing
PB	Preparation blank
PC	Polycarbonate
PCB	Polychlorinated biphenyl
PE	Performance evaluation
PE	Professional Engineer
PID	Photoionization detector
PNA	Polynuclear aromatic
POHC	Principal organic hazardous constituent
POTW	Publicly-owned treatment works
ppb	Parts per billion (e.g., µg/L or µg/Kg)
ppm	Parts per million (e.g., mg/L or mg/Kg)
ppt	Parts per trillion
PQL	Practical quantitation limits
PRP	Potentially responsible party
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
QA	Quality assurance
QAMS	Quality assurance management systems
QAMS	Quality assurance management staff
QAPP	Quality assurance project plan
QC	Quality control
QCSR	Quality control summary report
RA	Remedial action
RAS	Routine analytical services
RC	Remedial construction
RCRA	Resource Conservation Recovery Act
RD	Remedial design
RDX	Royal demolition explosive
RF	Response factor
RFA	RCRA facility assessment
RFI	RCRA facility investigation
RI/FS	Remedial investigation/feasibility study
RMCL	Recommended maximum contaminant level
ROD	Record of decision
ROE	Right of entry
RPD	Relative percent difference
RPM	Remedial Project Manager
RQ	Reportable quantities
RRT	Relative retention time
RSD	Relative standard deviation
S & A	Supervision and administration
SAP	Sampling and analysis plan

SARA	Superfund Amendments and Reauthorization Act
SAS	Special analytical services
SDWA	Safe Drinking Water Act
SI	Site investigation
SGS	Soil gas survey
SITE	Superfund innovative technology evaluation
SMCL	Secondary maximum contaminant level
SOC	Synthetic organic compound
SOP	Standard operating procedures
SOW	Scope of work
SPCC	System performance check standard
SPE	Solid phase extraction
SPP	Sample preparation procedure
SQG	Small quantity generator
SRM	Standard reference material
SSHP	Site safety and health plan
SV	Sampling visit
SVE	Soil vapor extraction
SW-846	Solid waste analytical protocols
SWDA	Solid Waste Disposal Act
SWMU	Solid Waste Management Unit
TAL	Target Analyte List (CLP inorganics)
TAP	Toxic air pollutant
TAT	Technical assistance team
TBC	To be considered
TCE	Trichloroethylene
TCDD	Tetrachlorodibenzodioxin
TCDF	Tetrachlorodibenzofuran
TCL	Target Compound List (CLP organics)
TCLP	Toxicity characteristic leaching procedure
THM	Trihalomethane
TIC	Tentatively identified compound
TLC	Thin layer chromatography
TO	Toxic organics
TOC	Total organic carbon
TOX	Total organic halides
TPH	Total petroleum hydrocarbons
TRPH	Total recoverable petroleum hydrocarbons
TSCA	Toxic Substances Control Act
TSDF	Treatment, storage, disposal facility
TSWP	Treatability Study Work Plan
UIC	Underground injection control
USACE	U.S. Army Corps of Engineers
UST	Underground storage tank
UV	Ultraviolet
UXO	Unexploded explosive ordnance
VES	Vapor Extraction System
VOA	Volatile organic analysis (analyte)
VOC	Volatile organic compounds
VSI	Visual site inspection
WP	White phosphorus
WQC	Water quality criteria
XRF	X-ray fluorescence

Key Words and Definitions

Accuracy: the closeness of agreement between the measured value and the true value. Calculated as percent recovery.

Aliquot: a measured portion of a sample taken for analysis (USEPA CLP Statement of Work).

Analyte: a discrete chemical component of a sample to be identified and/or measured through analysis.

Anion: a negatively charged ion.

Aquifer: a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

Aromatic: relating to the six-carbon-ring configuration of benzene and its derivatives.

Background Concentrations or Levels: average presence in the environment (USEPA). Concentrations of contaminants detected in environmental samples from various media on the site or in the area of the site that have not been affected by site operations. These concentrations may reflect the natural occurrence of elements, as in the case of metals in soil. They may also reflect the widespread presence of compounds resulting from a variety of industrial and commercial activities, as in the case of PAHs in surface soils in urban areas.

- Regional background concentrations--usually apply to soil and reference data from a resource such as Shacklette and Boerngen, "Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States," 1984.

- Site-specific background concentrations--reference actual samples collected on the site or in the area of the site. Examples of such samples are groundwater samples from a monitoring well upgradient of the site or surface soil samples from an area that has not been affected by FMGP operations.

Bar Graph Spectrum: a plot of the mass-to-charge ratio (m/e) versus relative intensity of the ion current.

Batch: (analytical) batch is the basic unit for quality control implementation. The batch is defined as a group of ≤20, similar matrix samples and all of the required quality control (QC) samples which are analyzed together following the same method sequence, with the same manipulations, using the same reagents, during the same time period.

Boring: a cylindrical hole advanced into the ground, usually made by drilling.

4-Bromofluorobenzene (BFB): a compound chosen to establish mass spectral instrument performance for volatile analysis.

Calibration: determination of the ratio of instrument response to analyte concentration. Established by the analysis of standards containing analytes of interest at known concentrations.

Calibration Check Compounds (CCC): term used in conjunction with SW-846, method 8260 to refer to the compounds in which the percent RSD is evaluated against method-prescribed criteria to decide the validity of a calibration.

Calibration Standards (CAL): a set of solutions prepared from the primary standards solution with the internal standards and surrogate analytes, used to calibrate the instrument response with respect to analyte concentration.

Cation: a positively charged ion.

CERCLA/SARA: the Comprehensive Environmental Response and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986. The acronym CERCLA is frequently used to refer to both acts, as is the term Superfund. CERCLA requires the administrator of the USEPA to promulgate regulations (see NCP) designating hazardous substances that, when released into the environment, may present substantial danger to public health, welfare, or the environment. The act established the Superfund and required the promulgation of regulations governing the funding and cleanup of waste sites and contaminated areas. CERCLA is the act that establishes legislative authority, while the NCP is the regulation that implements the requirements of CERCLA.

Chemical Analysis: any of a variety of laboratory methods used to evaluate the concentrations of compounds and elements present in an environmental sample.

Cleanup Goals/Cleanup Standards/Cleanup Levels/Cleanup Criteria/Remediation Goals/Action Levels: for consistency, the following program usage is suggested:

- Action levels--1) to refer to the presence of a contaminant concentration in the environment high enough to warrant action or trigger a response under CERCLA or the NCP (USEPA).

Cleanup/Remediation/Remedial Action/Removal/Removal Action: for consistency, the following program usage is suggested:

- Remedial action--refers to all activities, except long-term operation and maintenance, associated with permanent correction or remedy of contamination at or in the area of a site.

- Removal action--refers to limited or short-term measures intended to mitigate the immediate effects of or prevent the release of hazardous substances into the environment (specifically, source removal).

- Cleanup or remediation--refers to all activities, including long-term operation and maintenance, associated with permanent correction or remedy of contamination at or in the area of a site.

Comparability: a qualitative characteristic which defines the extent to which a chemical parameter measurement is consistent with, and may be compared to, values from other sampling events.

Compatibility: the ability of materials (and/or wastes) to coexist without adverse effects.

Completeness: a quantitative evaluation of what percent of the chemical measurements (results) are successfully accomplished.

Composite Sample: portions of material collected from more than one spatial location or at different times that are blended and submitted for chemical analyses. Composite samples can provide data representative of a large area with relatively few samples. However, the resulting

data are less accurate with regard to the concentrations of contaminants detected in a specific location, because they represent average values.

Compound: a substance composed of two or more elements existing in combination. Each compound may be expressed by a chemical formula.

Continuing Calibration Standard (CCS): a mid-concentration analytical standard run periodically to verify the calibration of the analytical instrument. Also known as continuing calibration check (CCC).

Continuous Barrel Sampler: a 5-foot-long split barrel sampler used to collect representative samples of soil or soft rock. The sampler consists of five parts: a cutting shoe at the bottom, a barrel consisting of a length of pipe split longitudinally into two halves, a sample catcher, and a coupling at the top for connection to the drill rods.

Contract Laboratory Program (CLP): a nationwide laboratory network established by the USEPA, structured to provide legally defensible analytical results to support USEPA enforcement actions or other requirements of the user community. The CLP incorporates a level of quality assurance appropriately designed for the intended usage of the data.

Contractor Chemical Quality Control: a three-phase control process (preparatory, initial, and follow-up) that is performed onsite by the contractor to ensure that quality is maintained throughout all field work.

Data Review: an evaluation of laboratory data quality based on a review of method-specific quality control documentation. Method-specific quality control documentation requirements are specified in the project-specific laboratory subcontract.

Data Validation: an evaluation of laboratory data quality based on a review of the data deliverables. This process involves procedures verifying instrument calibration, calibration verification, and other method-specific performance criterion.

Decontamination: cleaning of personnel, equipment, structural materials, etc., using any of a variety of technologies. The most commonly used technologies are 1) washing, using soap and water and/or various acidic rinses or solvents, etc., and 2) steam cleaning. This term applies both to cleaning of personnel and equipment following site investigation and remediation activities and to cleaning of contaminated structures or structural materials as part of a removal or remedial action.

Discrete Sample: a portion of material collected from a unique spacial location and submitted for chemical analyses. Discrete samples are collected when it is necessary to identify and quantify contamination at a specific location and time.

Disposal: final placement or destruction of wastes. Disposal may be accomplished through the use of landfills, treatment processes, etc.

Dissolved Metals: the concentration of metals determined in a sample which will pass through a 0.45-µm filter. The sample is filtered, the filtrate is preserved (acidified) in the field, transported to the lab, and then digested with hot dilute mineral acid.

Duplicate: see matrix duplicate.

Environmental Sampling: collection of samples from a particular media for the purpose of obtaining chemical analyses.

Equipment Rinsate Blank/Field Equipment Blank/Rinsate Blank/Equipment Blank: samples of clean, analyte-free water passed through and over the sampling equipment. These blanks permit evaluation of equipment decontamination procedures and potential cross-contamination of environmental samples between sampling locations. An equipment rinsate blank is typically obtained from each type of sampling tool used to collect environmental samples.

Extractable Organics: semivolatiles (base/neutral and acid extractable compounds) and pesticide/polychlorinated biphenyl compounds that can be partitioned into an organic solvent from the sample matrix and are amenable to gas chromatography (GC).

Feasibility Study (FS): a description and analysis of the potential cleanup alternatives for a hazardous waste site. Cleanup alternatives are broadly evaluated on the basis of effectiveness, implementability, and cost. The USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* specifies nine detailed evaluation criteria.

Field Blank: (Bottle blank) analyte-free (deionized) water transferred to the appropriate sample bottles in the field and submitted for analysis. Results assess the potential

incidental (airborne) contamination and cross-contamination due to the sample bottles and preservatives.

Field Control Samples: general term assigned to field-generated replicates (duplicates/splits/spikes), blanks, background/upgradient samples, etc.

Field Duplicate Sample: independent sample collected at approximately the same time and place, using the same methods as another sample. The duplicate and original sample are containerized, handled, and analyzed in an identical manner.

Field Investigation: any investigation conducted at a site or in the area of a site for the purpose of site characterization. A field investigation may or may not be part of an RI or an RA. It may include geophysical surveys, ground surveys, well surveys, environmental sampling, etc.

Field QA Split: a sample that is a (collocated or homogenized) replicate of a field sample, except that the sample is sent to the government QA laboratory for analysis. Sample receipt allows early detection of sampling, documentation, packaging, and/or shipping errors. Data comparison to contractor's data allows an assessment of lab's performance.

Field QC Sample: a field replicate (duplicate) sent blindly to the Contractor's (primary) laboratory. Results assess the sampling precision and handling techniques.

Field Replicate: a general term for field duplicates/triplicates, field splits, or field spikes. Samples may be homogenized prior to splitting into replicate samples. Each replicate is containerized, handled, and analyzed in an identical manner. Used to evaluate the precision of handling, shipping, storage, preparation, and analysis.

Filtrate: a filtered liquid.

Filtration: the physical removal of solid particles from a liquid wastestream by passing the liquid across a filter medium, which serves as a barrier to the solid material.

FSP: (Field Sampling Plan). The portion of the SAP which defines the field activities; includes all requirements for sampling, field documentation, onsite chemical analysis, sample packaging and shipping, etc.

Gas Chromatography/Mass Spectroscopy (GC/MS): two distinct analytical techniques used to separate and identify organic compounds: the GC is used for the separating portion and the MS is used as the detection portion of an analysis. Both techniques are typically performed by a single instrument.

Grab Sample: an individual sample collected from a single location at a specific time. Samples are collected and placed in the appropriate sample containers with no mixing.

Hazardous/Nonhazardous: the following terms are correct:

- Hazardous waste (RCRA)--as defined in 40 CFR 261, byproducts of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Refers to both wastes listed in the referenced section and wastes demonstrating any of the four hazardous characteristics (ignitability, corrosivity, reactivity, and toxicity) identified in the referenced section.

- Hazardous substance (CERCLA)--encompasses not only RCRA hazardous wastes, but also includes substances and pollutants listed under the Clean Water Act; hazardous air pollutants listed under the Clean Air Act; any substance with respect to which the USEPA has taken action under TSCA; and elements, compounds, mixtures, solutions, and substances (to be identified by the USEPA under CERCLA) which, when released into the environment may present substantial danger to the public welfare or the environment.

- Hazardous material (DOT)--refers to materials contaminated by any substance that is listed in the appendix to 49 CFR 172.101 and that exceeds the reportable quantity criteria identified in this appendix.

- Nonhazardous--if used, clarify whether it is used as the opposite of one or all of the terms defined above, or whether it refers to the absence of toxic characteristics as defined by risk assessment techniques, etc.

Heavy Metals: in reference to environmental sampling, typically identified as the following trace inorganics: cadmium, lead, mercury, silver, etc. (all metals of health concern). Heavy metals can cause biological damage if consumed at low concentrations and tend to accumulate in the food chain.

Heterogenous: the quality of containing dissimilar parts within the media's composition.

High Performance Liquid Chromatography (HPLC): an analytical technique used for separating and identifying compounds not amenable to gas chromatography.

Homogeneous: the quality of uniform composition.

Homogenized Sample: a sample which is collected from a single location at a specific time, but is mixed to ensure representativeness prior to containerizing. This technique is not suitable for volatile organic samples.

Hydrogeologic Investigation: a systematic study of the interrelationships that exist between geology and the associated ground and surface water.

Hydrogeology: the study of the interrelationships of geologic materials and processes with water, especially groundwater.

Hydrology: the study of the occurrence, distribution, and chemistry of all waters of the earth.

Infiltration: the penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls.

Initial (Continuing) Calibration Blank (ICB/CCB): a volume of ASTM II (polished) water prepared in the same manner as standards used to flush the analytical system.

Initial (Continuing) Calibration Verification Standard (a.k.a. instrument check standard) (ICV/CCV): An EPA-certified multi-element standard or independently prepared multi-element standard solution used to verify the accuracy of the initial calibration. This standard prepares all elements at concentrations of known concentrations equivalent to the midpoint of their respective calibration curves and must be run at each wavelength used in the ICP analysis.

Inorganic Chemicals: chemical substances of mineral origin, not of basically carbon structure.

Interference (Interelement) Check Standard (ICS or IEC): a solution containing both interfering and analyte elements of known concentrations is used to verify background and/or interelement interferences, so that appropriate correction factors are utilized to compensate.

Internal Standards (IS): Compounds added to every standard, blank, sample, matrix duplicate, matrix spike, matrix spike duplicate, etc., at a known concentration, prior to analysis. Internal standards are used as the basis for quantitation of the target compounds.

Laboratory Control Sample (LCS): also referred to as a QC (Reference) Sample. A spiked blank sample prepared by the analyst (preferably obtained from an outside source) which combines a portion, or all of the elements being analyzed for calculation of precision and accuracy to verify that analysis is being performed in control. Depending upon the method being followed, this analysis may be required quarterly, or in response to matrix-specific QC criteria failure.

Laboratory Duplicate Samples: identical splits of individual samples that are taken and analyzed by the laboratory to assess method reproducibility.

Laboratory Fortified Blank (LFB): A term used in conjunction with EPA 600/4-88/039, method 524.2, which describes an aliquot of reagent water to which known quantities of the method analytes are added in the laboratory. The LFB is analyzed exactly like a sample, and its purpose is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined in a separate aliquot and measured values in the LFM corrected for background concentrations.

(m/z): Mass-to-charge ratio. Synonymous with (m/e).

Matrix: The material of which the sample to be analyzed is composed. Typically, refers to water, soil/sediment, or other environmental medium. Matrix is NOT synonymous with phase (liquid, or solid).

Matrix Duplicate / Laboratory Duplicate (DUP): Two representative aliquots of the same sample matrix subjected to identical analytical procedures in order to assess the procedural precision of the method through the calculation of relative percent difference (%RPD).

Matrix Spike: Also referred to as a Laboratory Fortified Sample Matrix (LFM). An aliquot of sample matrix (soil or water) fortified with known quantities of specific compounds and subjected to the entire analytical procedure in order to assess the appropriateness of the method to the matrix through calculation of the percent recovery, or other accuracy term.

Matrix Spike Duplicate: a second aliquot of the same matrix as the matrix spike that is fortified also in order to determine the precision of the method.

Medium/Media: refers to the basic material composing an environmental sample or an environment of regulatory concern, i.e., water, soil, or air. "Medium" is singular, "media" is plural. This term derives from the conventional definition: "the element (earth, water, air, or fire) that is the natural habitat of an organism)."

Method Blank (MB): also known as Reagent Blank (RB), or Laboratory Reagent Blank (LRB). A volume of ASTM II (polished) water prepared in the same manner as samples. This sample is used to evaluate if cross contamination or any memory effects are present.

Method Detection Limit (MDL): minimum concentration of a substance that can be measured and reported.

Method of Standard Additions (MSA): the method of standard addition may be required to compensate for matrix effects. This technique should not be used for interferences which cause baseline shift. The standard-addition technique involves the analysis of the unknown sample and unknown plus known amounts of standard with extrapolation of this internal calibration curve to the baseline.

µg/kg: a unit describing the concentration of substances within a solid medium's mass (weight) (ppm = parts per billion).

µg/L: a unit describing the concentration of substances within a liquid medium's volume (ppm = parts per billion).

mg: (milligram) unit of measure for mass (weight) (1,000 mg = gram).

mg/kg: a unit describing the concentration of substances within a solid medium's mass (weight) (ppm = parts per million).

mg/L: a unit describing the concentration of substances within a liquid medium's volume (ppm = parts per million).

mg/m^3: a unit describing the concentrations of dusts, gases, and mists in a measured amount of air.

Mixed Waste: waste material which contains hazardous chemical and radioactive constituents.

Multimedia: containing or involving more than one medium.

National Oil and Hazardous Substances Contingency Plan (NCP): this is the rule that implements the regulatory requirements of CERCLA and SARA. It guides the determination of the sites to be corrected under the Superfund program and the program to prevent or control spills into surface waters or other portions of the environment.

National Priority List (NPL): the USEPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. The list is based primarily on the score a site receives from the Hazard Ranking System. EPA is required to update the NPL at least once a year.

Negative Pressure: indirect pressure applied to the liquid in the form of a vacuum drawing the liquid through a filter membrane.

Onsite/Offsite: (refer to definitions of site):

- Onsite--within the site boundaries.
- Offsite--outside the site boundaries.

Organic: 1) referring to or derived from living organisms. 2) In chemistry, any compound containing carbon.

pH: a numerical designation of relative acidity or basicity (alkalinity). A pH of 7 indicates neutrality; lower values indicate increasing acidity; higher values indicate increasing alkalinity.

Physical Soil Analysis: an analysis used to determine the physical and engineering properties of a soil. Possible analyses may include: particle size, dry weight, Atterberg limits, pH, redox potential, mineral class, organic carbon and clay content, density, soil porosity, compaction, and consolidation.

Positive Pressure: pressure that is applied directly on a liquid, forcing it through the filter membrane.

Practical Quantitation Limit (PQL): minimum concentration of a substance that can be reported based upon the analysis of a project specific matrix.

Precision: agreement among the results from a set of duplicate analysis, regardless of the true value.

Preservation: methods used to retard degradation of chemical analytes within samples by inhibiting decomposition by biological action, chemical reactions, and reducing sorption effects. Methods include limiting headspace, chemical, acid, or base addition, protection from light, cooling, etc.

Purge and Trap Device: analytical technique used to isolate volatile (purgeable) organics by stripping the compounds from water or soil by a stream of inert gas, trapping the compounds on an adsorbent such as a porous polymer trap, and thermally desorbing the trapped compounds onto a gas chromatographic column.

Purging: removing from a well stagnant water that may bias representative samples. Purge volume usually varies between 3 and 5 times the volume of the well.

QAPP: (Quality Assurance Project Plan). The portion of the SAP which defines the laboratory analytical and chemical data reporting requirements.

QC Reference Standard: Refer to LCS.

QC Laboratory: the USACE Division (referee) laboratory which is responsible for the analyses of the project QA (split) samples.

Quality Assurance/Quality Control (QA/QC): a system of procedures, checks, audits, and corrective actions to ensure that all research, design, performance, environmental monitoring and sampling, and other technical and reporting activities are of the highest achievable quality (USEPA).

Relative Percent Difference (RPD): Calculation used to compare two values and assess against method precision criteria. Refer to Appendix B for further information.

(Relative) Response Factor (RF/RRF): A measure of the relative mass spectral response of an analyte compared to its internal standard. RF/RRF are determined by analysis of standards and are used in the calculation of concentrations of analytes in samples. RF/RRF is calculated from the following equation:

$$RF = \frac{(A_x C_{IS})}{(A_{IS} C_X)}$$

where:

A_x = area of the characteristic ion for the compound being measured

A_{IS} = area of the characteristic ion for the specific internal standard

C_X = concentration of the compound being measured

C_{IS} = concentration of the specific internal standard

Release: any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment excluding any release that results in exposure to persons solely within a workplace; emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel, or pipeline pumping station engine; and release of source, byproduct, or special nuclear material from a nuclear incident (NCP).

Remedial Design (RD): the technical analysis and procedures that follow the selection of remedy for a site and result in a detailed set of plans and specifications for implementation of the remedial action (NCP).

Remedial Investigation (RI): a process undertaken to determine the nature and extent of the problem presented by the release of hazardous substances into the environment (USEPA). The RI includes sampling and monitoring, and includes gathering sufficient information to establish cleanup criteria, to determine the necessity for remedial action, and to support the evaluation of remedial alternatives. The RI process is usually considered to encompass obtaining resources required for the field investigation, the field investigation itself, and the RI report.

Representativeness: a qualitative measure of the extent to which a sample(s) acquired from a medium describe the chemical characteristics of that medium.

Residual: pertaining to a residue or remainder, as in "residual contamination." Amount of pollutant remaining in the environment after a natural or technological process has taken place, for example, the sludge remaining after initial wastewater treatment or particulates remaining in air after the air passes through a scrubbing or other pollutant removal process.

Resolution: also known as separation, or percent resolution. The separation between peaks on a chromatogram, calculated by dividing the depth of the valley between the

peaks by the peak height of the smallest peak being resolved, and multiplied by 100.

Resource Conservation and Recovery Act (RCRA): refers to the Solid Waste Disposal Act as amended by RCRA. This act is codified in 40 CFR 240-272 and includes regulations governing solid wastes, which include hazardous wastes as defined under RCRA. The RCRA hazardous regulations govern all aspects of hazardous waste management including identification and listing of hazardous wastes and standards applicable to generators; transporters; and owners of treatment, storage, and disposal facilities.

RI-derived Waste: any wastes generated during remedial investigation activities that may have come in contact with contaminated media at the site. These wastes usually include drilling cuttings, well development or purging water, personnel protective clothing, and plastic used to collect cuttings.

Risk Assessment: qualitative and quantitative evaluation performed to define the risk posed to human health and/or the environment by the presence of specific pollutants.

Sample: a portion of material collected for chemical analyses. Note that a sample is identified by a unique sample number and that the term and the number may apply to multiple sample containers, if a single sample is submitted for a variety of chemical analyses.

SAP: (Sampling and Analysis Plan). A submittal document comprised of the FSP and QAPP; used to define all aspects of the project sampling and analytical work to be done.

Sediment: solid material settled from suspension in a liquid.

Semivolatile Organics: compounds that are amenable to analysis by extraction of the sample with an organic solvent. The term semivolatile organic is used synonymously with base/neutral/acid (BNA) compounds.

Sensitivity: the capability of a method or instrument to discriminate between small differences in analyte concentration.

Serial Dilution: when a new or unusual matrix is encountered, a series of tests is recommended prior to release of results to verify that no matrix effects are occurring. The method recommends 1:4 dilution be run on samples >10X IDL, with results agreeing within ± 10% of the original determination.

Sludge: any heavy, slimy deposit, sediment, or mass.

Slug Test: an aquifer test conducted by causing an instantaneous change in the water level in a well. The recovery of the water level with time is measured.

Soil: a natural aggregate of mineral grains with or without organic materials that can be separated by mechanical means.

Solids: materials that tend to keep their form rather than to flow or spread out.

Split-spoon Sampler: open-ended cylindrical tool used to collect samples by driving or pushing them into the ground. Split-spoon samplers have inside diameters ranging from 1-3/8 to 2-1/2 in. and usually consist of five parts, similar to a continuous barrel sampler.

Subsurface: below the land surface.

Subsurface Investigation: a systematic study of the physical and chemical properties of the geologic materials, groundwater, and any waste products present in the subsurface.

Subsurface Soil: soil that underlies the defined limit of surface soil. Distinction between surface soil and subsurface soil is only valid when referring to risk posed by exposure of surface biota to contamination.

Superfund: the program operated under the legislative authority of CERCLA and SARA that funds and carries out the USEPA solid waste emergency and long-term removal remedial activities. These activities include establishing the National Priority List, investigating sites for inclusion on the list, determining their priority level on the list, and conducting and/or supervising the ultimately determined cleanup and other remedial actions.

Surrogate Compounds: Also referred to as System Monitoring Compounds (SMC). Brominated, fluorinated, or isotopically labelled compounds (not expected to be detected within environmental samples) which are added to EVERY blank, sample, MS, MSD, DUP, standard, etc. in order to evaluate analytical efficiency by measuring recovery.

Suspended Metals: The concentration of metals determined in the portion of a sample that is retained on a 0.45-µm filter. (The concentration of suspended metals may also be calculated from the difference between the total metals sample results minus the dissolved metals sample results.)

SW-846: a set of EPA reference manuals entitled *Test Methods for Evaluating Solid Waste*, 3rd edition, 1986, containing specific methods/procedures for physical and chemical analyses.

System Performance Check Compounds (SPCCs): Term used in conjunction with SW-846, method 8260, to refer to the compounds in which the RF is evaluated against method-prescribed criteria to decide the validity of a calibration.

Temperature Blank: a container filled with water which is packaged along with the field samples to allow the receiving laboratory a mechanism to accurately measure the temperature of the cooler and associated samples upon receipt. The samples do not undergo any chemical analysis.

Tentatively Identified Compounds (TICs): Compounds detected in samples that are not method target analytes, internal standards, or surrogates. Typically the ten largest previously unidentified peaks for VOA analysis are subjected to the mass spectral library searches for tentative identification. An additional charge may be associated with this procedure.

Thin-Wall Tube Sampler: a seamless steel tube with a diameter not less than 2 in. and an area ratio of about 10 percent. Common tubing used has a diameter of 2 or 3 in. and varies from 2 to 3 ft long. The lower end of the tube is crimped to form a cutting edge. The upper end is attached to a coupling head. Thin-walled tubes are used in soft or moderately stiff cohesive soils to collect relatively undisturbed unconsolidated material.

Total Metals: concentration of metals determined in an unfiltered water sample which is preserved (acidified) in the field, transported to the laboratory, and then follows a rigorous digestion.

Total Recoverable Metals: concentration of metals in an unfiltered water sample which is preserved (acidified) in the field and transported to the lab, which then performs the digestion with hot dilute mineral acid. This preparation method is typically utilized for drinking water samples and EPTox or TCLP extracts.

Trip Blank: samples prepared by adding clean, analyte-free water to sample containers for analysis for volatile organics. Preservatives are added to the blank, and the containers are sealed prior to the sampling trip. Trip blanks are transported with empty sample containers to the site of work and remain sealed until analyzed with collected environmental samples. Trip blanks permit evaluation of contamination generated from sample containers or occurring during the shipping and laboratory storage process.

Upgradient Sample: refers to background samples, with regard to upstream aqueous media (e.g., surface and groundwaters).

Volatile Organics: compounds amenable to analysis by the purge and trap technique. The term volatile organics is used synonymously with purgeable compounds.

Wide Bore Capillary Column: A gas chromatographic column with an internal diameter that is > 0.32 mm. Columns with lesser diameters are classified as narrow bore capillary columns.

Appendix K
Sampling and Analysis Plan Review Checklist

Sampling and Analysis Plan (SAP)
Review Checklist

Project Name:_____

Project Location: _____

GENERAL

Title Page

a. Is project title listed? Y__ N__ N/A__
b. Are names of principal investigators listed? Y__ N__ N/A__
c. Are approval/signature lines for responsible parties listed? Y__ N__ N/A__
d. Are abbreviations and acronyms listed? Y__ N__ N/A__

Table of Contents

a. Is list of essential elements present? Y__ N__ N/A__
b. Is list of figures present? Y__ N__ N/A__
c. Is list of tables present? Y__ N__ N/A__
d. Is list of appendices present? Y__ N__ N/A__

FIELD SAMPLING PLAN

Project Description

(This information may be referenced to the Project Work Plan.)

a. Is site location/description discussed? Y__ N__ N/A__
b. Is site map present? Y__ N__ N/A__
c. Is site history discussed? Y__ N__ N/A__
d. Is description of soils, geology, and hydrogeology at site discussed? Y__ N__ N/A__
e. Are previous investigations/reports described? Y__ N__ N/A__

Project Organization and Responsibilities

(This information may be referenced to the Project Work Plan.)

a. Is responsible organization identified? Y__ N__ N/A__
b. Are subcontractors identified? Y__ N__ N/A__
c. Are lines of authority identified? Y__ N__ N/A__

Scope and Objectives of the Field Investigation

a. Is the purpose of the investigation described? Y__ N__ N/A__
b. Are the objectives of the investigation identified for each medium of concern? Y__ N__ N/A__
c. Are background data summarized? Y__ N__ N/A__
d. Are data gaps identified for each medium? Y__ N__ N/A__

Field Investigation Rationale

a. Is rationale for geophysical investigations identified? Y__ N__ N/A__
b. Are summary figures/tables identifying sampling locations/ analytical analyses by medium included? Y__ N__ N/A__
c. Groundwater investigation
   1. Is the rationale for monitoring well locations clear? Y__ N__ N/A__
   2. Are upgradient wells or background well locations included? Y__ N__ N/A__
   3. Will well locations define vertical and horizontal extent of contamination? Y__ N__ N/A__
   4. Is the rationale for the well depth/screen depth discussed? Y__ N__ N/A__
   5. Is the rationale for slug tests/pump tests discussed? Y__ N__ N/A__
   6. Is the rationale for the sampling locations/sampling frequency and type of analyses and measurements discussed? Y__ N__ N/A__
   7. Is the rationale and frequency for the QC samples discussed? Y__ N__ N/A__
   8. Are QC samples required to be associated with critical samples? Y__ N__ N/A__

d. Subsurface Soil Investigations
   1. Is the rationale for soil boring locations clear? Y__ N__ N/A__
   2. Are background soil borings included? Y__ N__ N/A__
   3. Will soil borings define vertical and horizontal extent of contamination? Y__ N__ N/A__
   4. Is the rationale for geophysical testing discussed? Y__ N__ N/A__
   5. Is the rationale for the sampling locations/sampling frequency and type of analyses discussed? Y__ N__ N/A__
   6. Are soil samples for geotechnical analysis discussed? Y__ N__ N/A__
   7. Are field screening techniques described?/Are purpose and criteria identified? Y__ N__ N/A__
   8. Are the rationale and frequency for the QC samples discussed? Y__ N__ N/A__
   9. Are QC samples required to be associated with critical samples? Y__ N__ N/A__

e. Surface Soil Investigation
   1. Is the rationale for the soil sampling locations clear? Y__ N__ N/A__
   2. Is a soil sampling grid defined? Y__ N__ N/A__
   3. Will the soil sampling locations define the horizontal extent of contamination? Y__ N__ N/A__
   4. Are background soil samples included? Y__ N__ N/A__
   5. Is the rationale for the sampling locations/sampling frequency and type of analyses discussed? Y__ N__ N/A__
   6. Are field screening techniques described?/Are purpose and criteria identified? Y__ N__ N/A__
   7. Are the rationale and frequency for the QC samples discussed? Y__ N__ N/A__
   8. Are QC samples required to be associated with critical samples? Y__ N__ N/A__

f. Sediment Investigation
   1. Is the rationale for the sediment sampling locations clear? Y__ N__ N/A__
   2. Are background sediment samples included? Y__ N__ N/A__
   3. Will the sediment samples define the extent of contamination? Y__ N__ N/A__
   4. Is the rationale for the sampling frequency and type of analyses discussed? Y__ N__ N/A__
   5. Are field screening techniques described?/Are purpose and criteria identified? Y__ N__ N/A__
   6. Are the rationale and frequency for the QC samples discussed? Y__ N__ N/A__
   7. Are QC samples required to be associated with critical samples? Y__ N__ N/A__

g. Surface Water Investigation
   1. Is the rationale for the surface water sampling locations clear? Y__ N__ N/A__
   2. Are background samples included? Y__ N__ N/A__
   3. Will the surface water samples define the extent of contamination? Y__ N__ N/A__
   4. Is the rationale for the sampling locations/sampling frequency and type of analyses discussed? Y__ N__ N/A__
   5. Are field screening techniques described?/Are purpose and criteria identified? Y__ N__ N/A__
   6. Are the rationale and frequency for the QC samples discussed? Y__ N__ N/A__
   7. Are QC samples required to be associated with critical samples? Y__ N__ N/A__

Specific Field Investigation Activities/Procedures
a. Is a summary table of requirements for sample containers, preservation methods, holding time, and sample quantities presented? Y__ N__ N/A__
b. Drilling/Well Installation
   1. Is the drilling method specified? Y__ N__ N/A__
   2. Will the auger/drill stem and rig be decontaminated between holes? Y__ N__ N/A__
   3. Is the length of the well screen defined? Y__ N__ N/A__
   4. Is well screen placement consistent with contaminant location? Y__ N__ N/A__
   5. Are the materials used for the well screen and casing consistent with contaminant type? Y__ N__ N/A__
   6. Is thickness of well casing adequate for depth of well installation? Y__ N__ N/A__
   7. Is a typical well diagram provided? Y__ N__ N/A__
   8. Is there a minimum of 2 in. of annular space around the screen? Y__ N__ N/A__
   9. Is screen slot size appropriate for the size? Y__ N__ N/A__
   10. Does filter pack extend 2 to 3 ft above the screen? Y__ N__ N/A__
   11. Is bentonite seal to be adequately hydrated or fine sand placed to prevent grout intrusion? Y__ N__ N/A__
   12. Is grout placed appropriately and to the proper level? Y__ N__ N/A__
   13. Are the wells adequately protected? Y__ N__ N/A__
   14. Do aboveground installations have a drainhole near the base of the protective casing? Y__ N__ N/A__
   15. Does well have a lockable well cap for security? Y__ N__ N/A__
   16. Is the concrete/gravel pad around the well adequate? Y__ N__ N/A__
   17. Are the well coordinates and elevations surveyed? Y__ N__ N/A__
   18. Will wells be developed by bailing and purging? Y__ N__ N/A__
   19. Is well development record maintained? Y__ N__ N/A__
   20. Will field measurements of the groundwater be taken? Y__ N__ N/A__
   21. Are soil borings properly backfilled/abandoned? Y__ N__ N/A__
   22. Will soil borings be logged by a geologist-geotechnical engineer? Y__ N__ N/A__
   23. Are logging procedures discussed? Y__ N__ N/A__
   24. Are rock cores logged and photographed? Y__ N__ N/A__
   25. Is disposal of soil cuttings, well development water, decontamination water, and other wastes addressed? Y__ N__ N/A__
   26. Is a sample boring log with a scale provided? Y__ N__ N/A__
   27. Is a list of field equipment provided? Y__ N__ N/A__
   28. Are sample well installation diagram and development record form provided? Y__ N__ N/A__
   29. Are all standard field parameters to be recorded? Y__ N__ N/A__
   30. Is a hard-bound logbook maintained? Y__ N__ N/A__
   31. Are slug test procedures described? Y__ N__ N/A__

c. Groundwater Sampling
1. Are water level measurements taken before well purging? Y__ N__ N/A__
2. Are 3 to 5 well volumes purged prior to sampling the well? Y__ N__ N/A__
3. Are sampling devices described? Y__ N__ N/A__
4. Are purging devices described? Y__ N__ N/A__
5. Is filtration method described for collecting sample for dissolved metals? Y__ N__ N/A__
6. Are methods to obtain field measurements (pH, temperature, specific conductivity) described? Y__ N__N/A__
7. Are sampling devices decontaminated between samples? Y__ N__N/A__
8. Are procedures for collecting QA/QC samples addressed? Y__ N__N/A__
9. Are trip blanks sent with samples for volatile organic analysis? Y__ N__N/A__

d. Soil Sampling
1. Is sampling equipment described and appropriate for the purpose and site conditions? Y__ N__ N/A__
2. Are sample containers for volatiles filled before soil is composited? Y__ N__ N/A__
3. Is head space in sample containers for volatiles eliminated? Y__ N__ N/A__
4. Is sampling instrument decontaminated between samples? Y__ N__ N/A__
5. Are procedures for collecting QA/QC samples addressed? Y__ N__ N/A__
6. Are trip blanks sent with samples for volatile organic analysis? Y__ N__ N/A__

e. Sediment Sampling
1. Are sample locations referenced to a permanent structure and located with field measurements? Y__ N__ N/A__
2. Are sediment samples collected after surface water samples? Y__ N__ N/A__
3. Are sampling instruments appropriate? Y__ N__ N/A__
4. Are sampling instruments decontaminated between samples? Y__ N__ N/A__
5. Are excess water, sticks, rocks, and other debris removed before placing sediment into sample containers? Y__ N__ N/A__
6. Are procedures for collecting QA/QC samples addressed? Y__ N__ N/A__

f. Surface Water Sampling
1. Is surface water sample collected before sediment sample? Y__ N__ N/A__
2. Is depth of water measured? Y__ N__ N/A__
3. Are sampling instruments described and appropriate for purpose and site conditions? Y__ N__ N/A__
4. Are sampling procedures described? Y__ N__ N/A__
5. Are methods to obtain field measurements (pH, temperature, specific conductance) described? Y__ N__ N/A__
6. Are sampling instruments decontaminated between samples? Y__ N__ N/A__
7. Are procedures for collecting QA/QC samples described? Y__ N__ N/A__

g. Sample Packaging and Shipping
1. Are samples required to be chilled immediately after being collected? Y__ N__ N/A__
2. Are shipping coolers made of suitable material? Y__ N__ N/A__
3. Is empty space in cooler filled with insert packing material? Y__ N__ N/A__
4. Are bottles enclosed in clean plastic bags? Y__ N__ N/A__
5. Are sample tags affixed to sample containers? Y__ N__ N/A__

6. Are bottles placed upright in cooler in a way that they do not touch? Y__ N__ N/A__
7. Are bags of ice placed in coolers containing samples for chemical analysis? Y__ N__ N/A__
8. Is chain of custody form sealed in plastic bag and taped to inside lid of cooler? Y__ N__ N/A__
9. Is cooler drain taped shut? Y__ N__ N/A__
10. Is cooler lid secured with tape? Y__ N__ N/A__
11. Is completed shipping label taped to top of cooler? Y__ N__ N/A__
12. Are "This Side Up" labels placed on all four sides of cooler? Y__ N__ N/A__
13. Are "fragile" labels placed on two sides of coolers? Y__ N__ N/A__
14. Are signed custody seals affixed to the front right and left side of the coolers? Y__ N__ N/A__
15. Are medium/high concentration samples placed in metal cans and secured with three clips prior to placement in cooler? Y__ N__ N/A__
16. Are metal cans containing medium/high concentration samples properly labeled? Y__ N__ N/A__

h. Is a schedule for the field activities presented? Y__ N__ N/A__

i. Are daily quality control reports described? Y__ N__ N/A__
   1. Are notification and corrective action procedures discussed? Y__ N__ N/A__
   2. Are procedures to deviate from approved SAP described? Y__ N__ N/A__

j. Is disposal of RI-derived wastes properly documented? Y__ N__ N/A__

QUALITY ASSURANCE PROJECT PLAN (QAPjP)

Quality Assurance Objectives

(This information may be referenced to the Project Work Plan.)

a. Are field measurement objectives discussed? Y__ N__ N/A__
b. Are analytical method detection limits defined? Y__ N__ N/A__
c. Are quality control parameters defined? Y__ N__ N/A__
   1. Precision and accuracy Y__ N__ N/A__
   2. Completeness Y__ N__ N/A__
   3. Representativeness Y__ N__ N/A__
   4. Comparability Y__ N__ N/A__

Sample Custody/Documentation

a. Is a field logbook maintained with appropriate information concerning drilling/sampling? Y__ N__ N/A__
b. Is method of identifying photographs discussed? Y__ N__ N/A__
c. Is sample numbering system appropriate? Y__ N__ N/A__

   1. Project designator Y__ N__ N/A__
   2. Location designation Y__ N__ N/A__
   3. Matrix code Y__ N__ N/A__
   4. Sample sequence numbers Y__ N__ N/A__
   5. Depth interval (if required) Y__ N__ N/A__

d. Sample Documentation

1. Does information on sample label include:	Y__ N__ N/A__
-- Site name	Y__ N__ N/A__
-- Identification of sample station number	Y__ N__ N/A__
-- Date and time of collection	Y__ N__ N/A__
-- Name of sampler	Y__ N__ N/A__
-- Analytical analyses requested	Y__ N__ N/A__
-- Media sampled	Y__ N__ N/A__
-- Preservation method	Y__ N__ N/A__
2. Are completed custody seals required over sample container (except VOA) lids?	Y__ N__ N/A__
3. Does chain-of-custody record contain appropriate information?	Y__ N__ N/A__
4. Are receipts for sample forms required?	Y__ N__ N/A__
5. Are the step-by-step sample documentation procedures explained?	Y__ N__ N/A__
6. Are procedures to correct sample documentation explained?	Y__ N__ N/A__

Laboratory Analytical Procedures

a. Is laboratory QA plan available?	Y__ N__ N/A__
b. Are analytical methods specified?	Y__ N__ N/A__
c. Are detection limits specified?	Y__ N__ N/A__
d. Are performance and systems audits described and scheduled?	Y__ N__ N/A__
e. Is preventive maintenance addressed?	Y__ N__ N/A__
f. Are instrument calibration procedures and frequency addressed?	Y__ N__ N/A__
g. Are laboratory's data reduction, validation, and documentation and custody procedures addressed?	Y__ N__ N/A__
h. Are requirements for timing of data submittals, reporting format and contents, and recipients of data addressed?	Y__ N__ N/A__

CONCLUSION

_____ Approval Recommended

_____ Approval Recommended with Comments

_____ Resubmission Recommended

Reviewed: _____

Date: _____

Appendix C

U.S. Environmental Protection Agency, Region II

Ground Water Sampling Procedure

Low Stress (Low Flow) Purging and Sampling

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION II

GROUND WATER SAMPLING PROCEDURE
LOW STRESS (Low Flow) PURGING AND SAMPLING

I. SCOPE & APPLICATION

This Low Stress (or Low-Flow) Purging and Sampling Procedure is the EPA Region II standard method for collecting low stress (low flow) ground water samples from monitoring wells. Low stress Purging and Sampling results in collection of ground water samples from monitoring wells that are representative of ground water conditions in the geological formation. This is accomplished by minimizing stress on the geological formation and minimizing disturbance of sediment that has collected in the well. The procedure applies to monitoring wells that have an inner casing with a diameter of 2.0 inches or greater, and maximum screened intervals of ten feet unless multiple intervals are sampled. The procedure is appropriate for collection of ground water samples that will be analyzed for volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, and microbiological and other contaminants in association with all EPA programs.

This procedure does not address the collection of light or dense non-aqueous phase liquids (LNAPL or DNAPL) samples, and should be used for aqueous samples only. For sampling NAPLs, the reader is referred to the following EPA publications: DNAPL Site Evaluation (Cohen & Mercer, 1993) and the RCRA Ground-Water Monitoring: Draft Technical Guidance (EPA/530-R-93-001), and references therein.

II. METHOD SUMMARY

The purpose of the low stress purging and sampling procedure is to collect ground water samples from monitoring wells that are representative of ground water conditions in the geological formation. This is accomplished by setting the intake velocity of the sampling pump to a flow rate that limits drawdown inside the well casing.

Sampling at the prescribed (low) flow rate has three primary benefits. First, it minimizes disturbance of sediment in the bottom of the well, thereby producing a sample with low turbidity (i.e., low concentration of suspended particles). Typically, this saves time and analytical

costs by eliminating the need for collecting and analyzing an additional filtered sample from the same well. Second, this procedure minimizes aeration of the ground water during sample collection, which improves the sample quality for VOC analysis. Third, in most cases the procedure significantly reduces the volume of ground water purged from a well and the costs associated with its proper treatment and disposal.

III. ADDRESSING POTENTIAL PROBLEMS

Problems that may be encountered using this technique include a) difficulty in sampling wells with insufficient yield; b) failure of one or more key indicator parameters to stabilize; c) cascading of water and/or formation of air bubbles in the tubing; and d) cross-contamination between wells.

Insufficient Yield

Wells with insufficient yield (i.e., low recharge rate of the well) may dewater during purging. Care should be taken to avoid loss of pressure in the tubing line due to dewatering of the well below the level of the pump's intake. Purging should be interrupted before the water level in the well drops below the top of the pump, as this may induce cascading of the sand pack. Pumping the well dry should therefore be avoided to the extent possible in all cases. Sampling should commence as soon as the volume in the well has recovered sufficiently to allow collection of samples. Alternatively, ground water samples may be obtained with techniques designed for the unsaturated zone, such as lysimeters.

Failure to Stabilize Key Indicator Parameters

If one or more key indicator parameters fails to stabilize after 4 hours, one of three options should be considered: a) continue purging in an attempt to achieve stabilization; b) discontinue purging, do not collect samples, and document attempts to reach stabilization in the log book; c) discontinue purging, collect samples, and document attempts to reach stabilization in the log book; or d) Secure the well, purge and collect samples the next day (preferred). The key indicator parameter for samples to be analyzed for VOCs is dissolved oxygen. The key indicator parameter for all other samples is turbidity.

Cascading

To prevent cascading and/or air bubble formation in the tubing, care should be taken to ensure that the flow rate is sufficient to maintain pump suction. Minimize the length and diameter of tubing (i.e., 1/4 or 3/8 inch ID) to ensure that the tubing remains filled with ground water during sampling.

Cross-Contamination

To prevent cross-contamination between wells, it is strongly recommended that dedicated, in-place pumps be used. As an alternative, the potential for cross-contamination can be reduced by performing the more thorough ※daily※ decontamination procedures between sampling of each well in addition to the start of each sampling day (see Section VII, below).

Equipment Failure

Adequate equipment should be on-hand so that equipment failures do not adversely impact sampling activities.

IV. PLANNING DOCUMENTATION AND EQUIPMENT

- Approved site-specific Field Sampling Plan/Quality Assurance Project Plan (QAPP). This plan must specify the type of pump and other equipment to be used. The QAPP must also specify the depth to which the pump intake should be lowered in each well. Generally, the target depth will correspond to the mid-point of the most permeable zone in the screened interval. Borehole geologic and geophysical logs can be used to help select the most permeable zone. However, in some cases, other criteria may be used to select the target depth for the pump intake. In all cases, the target depth must be approved by the EPA hydrogeologist or EPA project scientist.

- Well construction data, location map, field data from last sampling event.

- Polyethylene sheeting.

- Flame Ionization Detector (FID) and Photo Ionization Detector (PID).

- Adjustable rate, positive displacement ground water sampling pump (e.g., centrifugal or bladder pumps constructed of stainless steel or Teflon). A peristaltic pump may only be used for inorganic sample collection.

- Interface probe or equivalent device for determining the presence or absence of NAPL.

- Teflon or Teflon-lined polyethylene tubing to collect samples for organic analysis. Teflon or Teflon-lined polyethylene, PVC, Tygon or polyethylene tubing to collect samples for inorganic analysis. Sufficient tubing of the appropriate material must be available so that each well has dedicated tubing.

- Water level measuring device, minimum 0.01 foot accuracy, (electronic preferred for tracking water level drawdown during all pumping operations).

- Flow measurement supplies (e.g., graduated cylinder and stop watch or in-line flow meter).

- Power source (generator, nitrogen tank, etc.).
- Monitoring instruments for indicator parameters. Eh and dissolved oxygen must be monitored in-line using an instrument with a continuous readout display. Specific conductance, pH, and temperature may be monitored either in-line or using separate probes. A nephalometer is used to measure turbidity.

- Decontamination supplies (see Section VII, below).

- Logbook (see Section VIII, below).

- Sample bottles.

- Sample preservation supplies (as required by the analytical methods).

- Sample tags or labels, chain of custody.

V. SAMPLING PROCEDURES

Pre-Sampling Activities

1. Start at the well known or believed to have the least contaminated ground water and proceed systematically to the well with the most contaminated ground water. Check the well, the lock, and the locking cap for damage or evidence of tampering. Record observations.

2. Lay out sheet of polyethylene for placement of monitoring and sampling equipment.

3. Measure VOCs at the rim of the unopened well with a PID and FID instrument and record the reading in the field log book.

4. Remove well cap.

5. Measure VOCs at the rim of the opened well with a PID and an FID instrument and record the reading in the field log book.

6. If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Note that the reference point should be surveyed for correction of ground water elevations to the mean geodesic datum (MSL).

7. Measure and record the depth to water (to 0.01 ft) in all wells to be sampled prior to purging. Care should be taken to minimize disturbance in the water column and dislodging of any particulate matter attached to the sides or settled at the bottom of the well.

8. If desired, measure and record the depth of any NAPLs using an interface probe. Care should be taken to minimize disturbance of any sediment that has accumulated at the bottom of the well. Record the observations in the log book. If LNAPLs and/or DNAPLs are detected, install the pump at this time, as described in step 9, below. Allow the well to sit for several days between the measurement or sampling of any DNAPLs and the low-stress purging and sampling of the ground water.

Sampling Procedures

9. Install Pump: Slowly lower the pump, safety cable, tubing and electrical lines into the well to the depth specified for that well in the EPA-approved QAPP or a depth otherwise approved by the EPA hydrogeologist or EPA project scientist. The pump intake must be kept at least two (2) feet above the bottom of the well to prevent disturbance and resuspension of any sediment or NAPL present in the bottom of the well. Record the depth to which the pump is lowered.

10. Measure Water Level: Before starting the pump, measure the water level again with the pump in the well. Leave the water level measuring device in the well.

11. Purge Well: Start pumping the well at 200 to 500 milliliters per minute (ml/min). The water level should be monitored approximately every five minutes. Ideally, a steady flow rate should be maintained that results in a stabilized water

level (drawdown of 0.3 ft or less). Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. As noted above, care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record each adjustment made to the pumping rate and the water level measured immediately after each adjustment.

12. Monitor Indicator Parameters: During purging of the well, monitor and record the field indicator parameters (turbidity, temperature, specific conductance, pH, Eh, and DO) approximately every five minutes. The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as follows (Puls and Barcelona, 1996):

    ±0.1 for pH
    ±3% for specific conductance (conductivity)
    ±10 mv for redox potential
    ±10% for DO and turbidity

    Dissolved oxygen and turbidity usually require the longest time to achieve stabilization. The pump must not be removed from the well between purging and sampling.

13. Collect Samples: Collect samples at a flow rate between 100 and 250 ml/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 ft. VOC samples must be collected first and directly into sample containers. All sample containers should be filled with minimal turbulence by allowing the ground water to flow from the tubing gently down the inside of the container.

    Ground water samples to be analyzed for volatile organic compounds (VOCs) require pH adjustment. The appropriate EPA Program Guidance should be consulted to determine whether pH adjustment is necessary. If pH adjustment is necessary for VOC sample preservation, the amount of acid to be added to each sample vial prior to sampling should be determined, drop by drop, on a separate and equal volume of water (e.g., 40 ml). Ground water purged from the well prior to sampling can be used for this purpose.

14. Remove Pump and Tubing: After collection of the samples, the tubing, unless permanently installed, must be properly discarded or dedicated to the well for resampling by hanging the tubing inside the well.

15. Measure and record well depth.

16. Close and lock the well.

VI. FIELD QUALITY CONTROL SAMPLES

Quality control samples must be collected to determine if sample collection and handling procedures have adversely affected the quality of the ground water samples. The appropriate EPA Program Guidance should be consulted in preparing the field QC sample requirements of the site-specific QAPP.

All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples should be collected during the sampling event:

- Field duplicates
- Trip blanks for VOCs only
- Equipment blank (not necessary if equipment is dedicated to the well)

As noted above, ground water samples should be collected systematically from wells with the lowest level of contamination through to wells with highest level of contamination. The equipment blank should be collected after sampling from the most contaminated well.

VII. DECONTAMINATION

Non-disposable sampling equipment, including the pump and support cable and electrical wires which contact the sample, must be decontaminated thoroughly each day before use (※daily decon※) and after each well is sampled (※between-well decon※). Dedicated, in-place pumps and tubing must be thoroughly decontaminated using ※daily decon※ procedures (see #17, below) prior to their initial use. For centrifugal pumps, it is strongly recommended that non-disposable sampling equipment, including the pump and support cable and electrical wires in contact with the sample, be decontaminated thoroughly each day before use (※daily decon※).

EPA's field experience indicates that the life of centrifugal pumps may be extended by removing entrained grit. This also permits inspection and replacement of the cooling water in centrifugal pumps. All non-dedicated sampling equipment (pumps, tubing, etc.) must be

decontaminated after each well is sampled (▒between-well decon,▒ see #18 below).

17. **Daily Decon**

A) Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

B) Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

C) Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D) Disassemble pump.

E) Wash pump parts: Place the disassembled parts of the pump into a deep basin containing 8 to 10 gallons of non-phosphate detergent solution. Scrub all pump parts with a test tube brush.

F) Rinse pump parts with potable water.

G) Rinse the following pump parts with distilled/ deionized water: inlet screen, the shaft, the suction interconnector, the motor lead assembly, and the stator housing.

H) Place impeller assembly in a large glass beaker and rinse with 1% nitric acid (HNO_3).

I) Rinse impeller assembly with potable water.

J) Place impeller assembly in a large glass bleaker and rinse with isopropanol.

K) Rinse impeller assembly with distilled/deionized water.

18. **Between-Well Decon**

A) Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

B) Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

C) Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D) Final Rinse: Operate pump in a deep basin of distilled/deionized water to pump out 1 to 2 gallons of this final rinse water.

VIII. FIELD LOG BOOK

A field log book must be kept each time ground water monitoring activities are conducted in the field. The field log book should document the following:

- Well identification number and physical condition.
- Well depth, and measurement technique.
- Static water level depth, date, time, and measurement technique.
- Presence and thickness of immiscible liquid layers and detection method.
- Collection method for immiscible liquid layers.
- Pumping rate, drawdown, indicator parameters values, and clock time, at three to five minute intervals; calculate or measure total volume pumped.
- Well sampling sequence and time of sample collection.
- Types of sample bottles used and sample identification numbers.
- Preservatives used.
- Parameters requested for analysis.
- Field observations of sampling event.
- Name of sample collector(s).
- Weather conditions.
- QA/QC data for field instruments.

IX. REFERENCES

Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation, C.K. Smoley Press, Boca Raton, Florida.

Puls, R.W. and M.J. Barcelona, 1996, Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures, EPA/540/S-95/504.

U.S. EPA, 1993, RCRA Ground-Water Monitoring: Draft Technical Guidance, EPA/530-R-93-001.

U.S. EPA Region II, 1989, CERCLA Quality Assurance Manual.

Appendix D
Horiba Model U-22 Multipurpose Probe

Field Environmental Instruments, Inc
Equipment Rental & Field Supplies

99 Miller Ave
Pittsburgh PA 15104
800-393-4009

Horiba U-22
Water Quality Monitoring System
Enhanced Model with Turbidity
ORP & Depth Function

The Horiba U-22 Monitoring System offers laboratory quality measurements in a portable package ready for use in though field conditions. The versatility & monitoring capabilities of the U-22 make it an excellent choice in lake, well, groundwater, ocean sewer and irrigation water applications.

Features

- Fits in two inch wells
- Up to one month data logging
- Measurement at depths as low as 100 meters
- Measures 10 parameters simultaneously; pH, DO, Conductivity, Salinity, TDS, Seawater specific gravity, Temperature, Depth, and ORP
- Automatic one point or manual two point calibration
- Immersed sensor detection
- Large digit LCD

Specifications

Parameters	Measuring Principle	Range	Resolution	Repeatability	Accuracy
pH • Two point calibration • Automatic Temp. Compensation	Glass Electrode Method	pH 0~14	0.01 pH	+/- 0.05 pH	+/- 0.1pH
Dissolved Oxygen • Salt correction (0 to 40ppt/automatic) • Automatic Temp Compensation	Diaphragm gavanic battery method	0~19.99 mg/L	0.01mg/L	+/-0.1mg/L	+/- 0.2mg/L
Conductivity • Auto Range • Automatic Temp conversion (25°C) • SI units	4 AC Electrode method	0~9.99S/m	0.1% F.S	+/-1%	+/-3%
Salinity	Conductivity conversion	0~4%	0.01%	+/-0.1%	+/-0.3%
TDS • Conversion factor setting	Conductivity conversion	0~99.9g/L	0.1% F.S	+/-2g/L	+/-5g/L
Seawater Specific Gravity • Display σt, σo, σ15	Conductivity conversion	0~50σt	0.1σt	+/-2σt	+/-5σt
Temperature	Thermistor method	0~55°C	0.01°C	+/-0.3°C	+/-1.0°C
Turbidity • Unit Selection	Penetration and scattering method	0~800 NTU	0.1 NTU	+/-3%	+/-5%
Water Depth	Pressure method	0~100m	1m	+/-3%	+/-5%
	Platinum electrode method	+/-1999mV	1mV	+/-5mV	+/-15mV

Main Unit: IP-67
Sensor Probe*:
Measurement Temp: 0~55°C
Storage Temp: -5~60°C
Measurement Depth: to 100m
Max. Probe size: 46mm
Probe Length: 380mm
Continuous Use: 30 days

* Organic solvents, strong acids, and strong alkaline solvents cannot be measured

"F.E.I. Your Needs are Our Business"

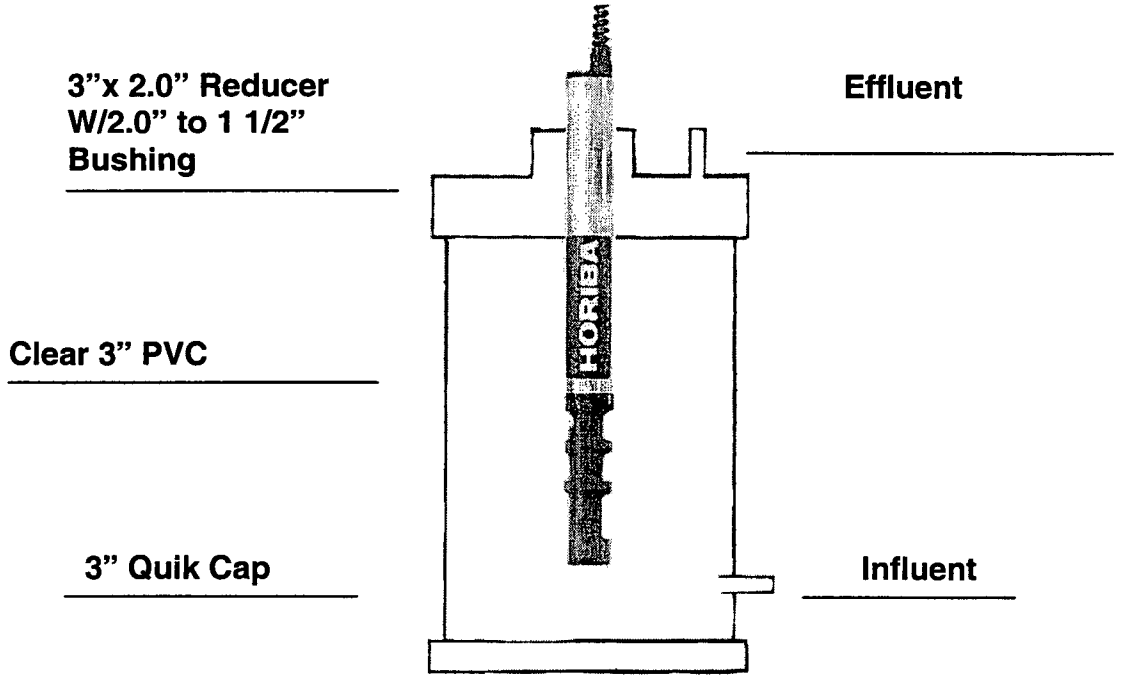
Phone: 800-393-4009 Fax: 412-271-5083 field@nauticom.net

FIELD ENVIRONMENTAL INSTRUMENTS

EQUIPMENT RENTAL & FIELD SUPPLIES

99 Miller Ave Pittsburgh PA 15104 Phone: 800-393-4009

Horiba U-22
Flow Thru Cell



The flow-thru cell can adapt to different size tubing by replacing the threaded fittings. Sizes are ½" 3/8", and ¼". (Fitting's are included.) Tighten the metal band around the neck to help prevent water leakage. Make sure the Horiba U-22 sensor guard is attached while using the instrument to prevent sensor breakage. Any questions, please call at Field Environmental.

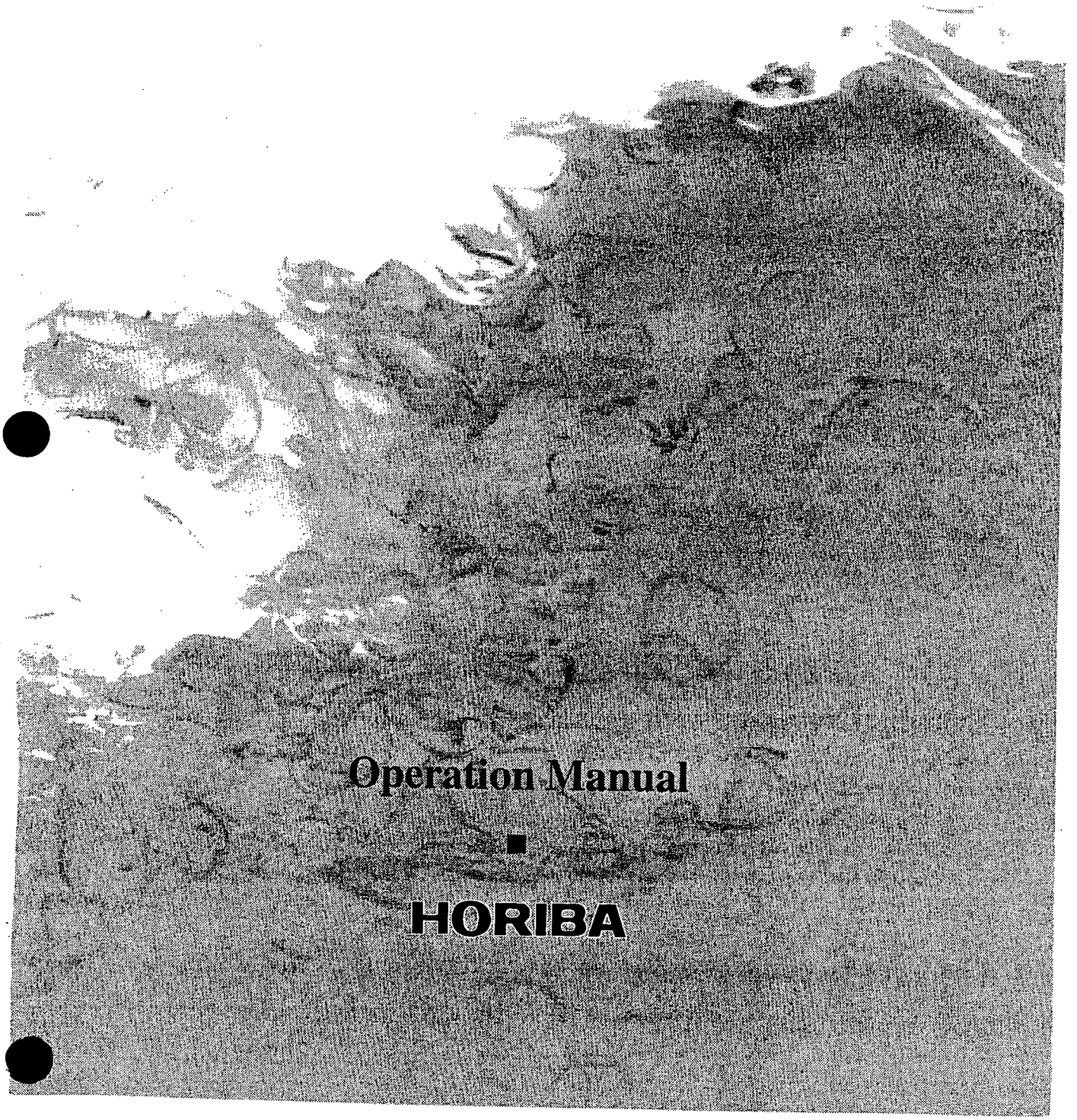
Call and Order Today!
800-393-4009

Fax Your Order 412-271-5083
Or
E-mail us at field@nauticom.net

MULTI-PARAMETER WATER QUALITY MONITORING SYSTEM

U-20 Series

U-22,23



Operation Manual

HORIBA

HORIBA's Warranty and Responsibility

Your U-20 series multi-parameter water quality monitoring system is covered by HORIBA's warranty for a period of one (1) year, under normal use. Although unlikely, if any trouble attributable to HORIBA should occur during this period, necessary exchange or repairs shall be conducted by HORIBA, free of charge. The warranty does not cover the following:

- Any trouble or damage attributable to actions or conditions specifically mentioned in the operation manuals to be avoided
- Any trouble or damage attributable to use of the multi-parameter water quality monitoring system in ways or for purposes other than those described in the operation manuals
- If any repairs renovations, disassembly, etc. are performed on this multi-parameter water quality monitoring system by any party other than HORIBA or a party authorized by HORIBA
- Any alteration to the external appearance of this multi-parameter water quality monitoring system attributable to scratches, dirt, etc. occurring through normal use
- Wear and tear to parts, the exchange of accessories, or the use of any parts not specified by HORIBA

Conformable Directive

CE

This equipment is in conformity with the following directives and standards:

Directives: The EMC Directives 89/336/EEC as amended by 91/263/EEC, 92/31/EEC and 93/68/EEC, in accordance with the Article 10 (1) of the Directive.

Standards: EN55011: 1991 Class B Group I
EN50082-1: 1992

FCC Warning

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Unauthorized reprinting or copying of this operation manual

No unauthorized reprinting or copying of all or part of this operation manual is allowed. The utmost care has been used in the preparation of this operation manual. If, however, you have any questions or notice any errors, please contact the HORIBA customer service printed on the back cover of this operation manual.

Preface

Thank you very much for purchasing HORIBA's "MULTI-PARAMETER WATER QUALITY MONITORING SYSTEM" U-20 Series.

Compact and one-hand-held, our multi-parameter water quality monitoring system makes measurements about a large number of items simultaneously.

The instrument uses a large-sized LCD display and has a variety of functions through easy operation, being useful for use at sites where measurements are to be made.

The water-proof construction of the instrument is compliant with IP-67 of IEC 529, "Water-proof test on electrical and mechanical equipment and tools and protection grade against entry of solids." Please use the instrument by following the information in this Operation Manual to maintain the water-proof construction of the instrument.

IP-67 standards

- Keeping dust and grit out of the instrument
- Up to 5°C difference between water and an instrument employed and no entry of water into. the inside of the instrument at a depth of 1 m for 30 minutes

This Operation Manual contains information on the basic way of handling the instrument, notes, etc. for the user. Be sure to read through the Operation Manual before use.

Symbols employed

The symbols employed herein have the following meanings:

⚠ **WARNING** : Improper use can result in serious injury or even death.

⚠ **CAUTION** : The improper use of the instrument may cause the following dangers:

- Danger of injury
- Danger of damage to the instrument, its peripherals, and data

Important : Explanation necessary for the proper operation of the instrument

Note : Explanation that is useful and necessary for handling the instrument

☞ : Refer to the item shown.

Symbols employed in screen description

The symbols  and  used in screen description have the following meanings:

 : The letters and numbers in this symbol are blinking on the screen.

 : The letters and numbers in this symbol are lighting up on the screen.

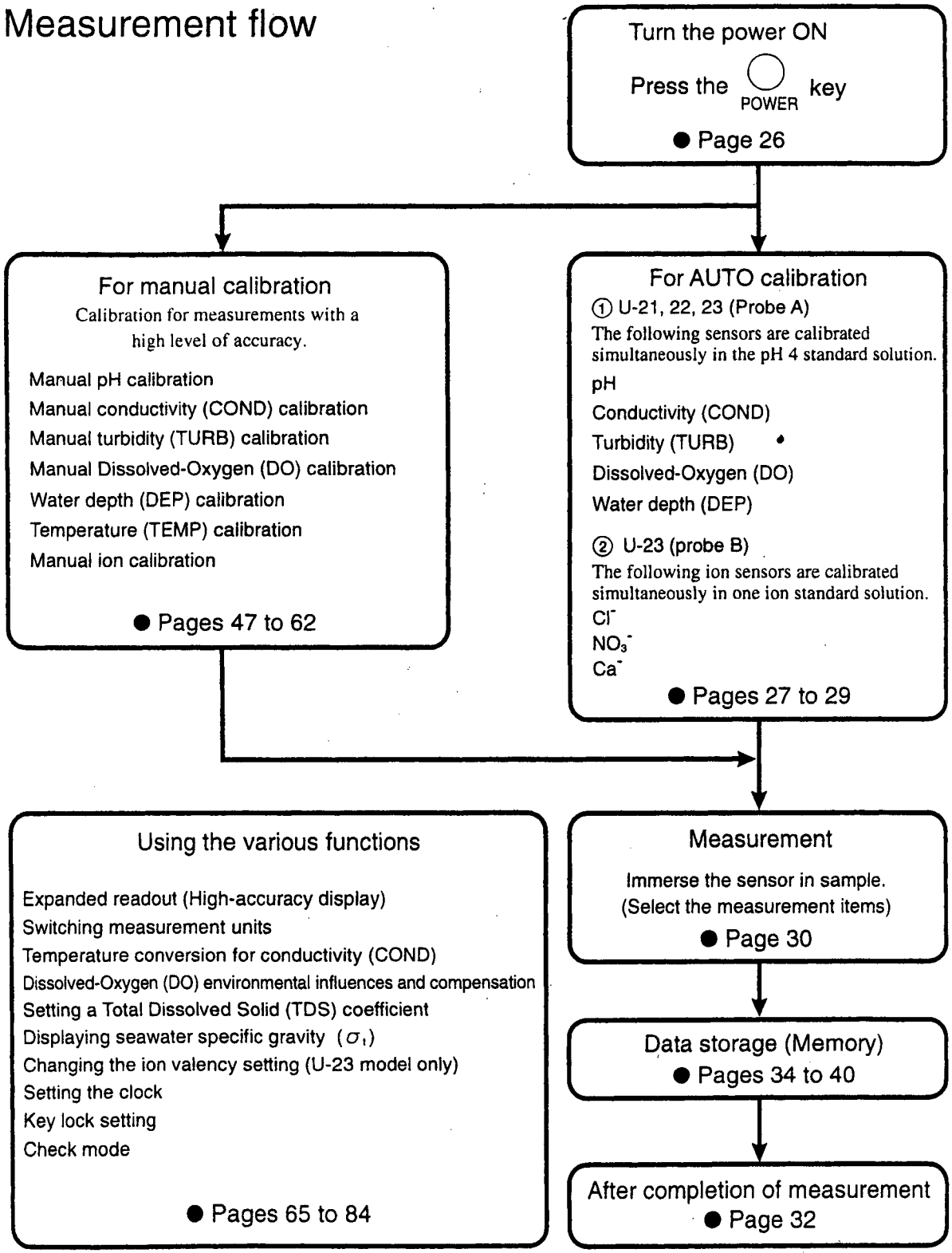
5. Techniques for more accurate measurement

6. Using the various functions

7. Instrument specifications

8. Reference data

Measurement flow

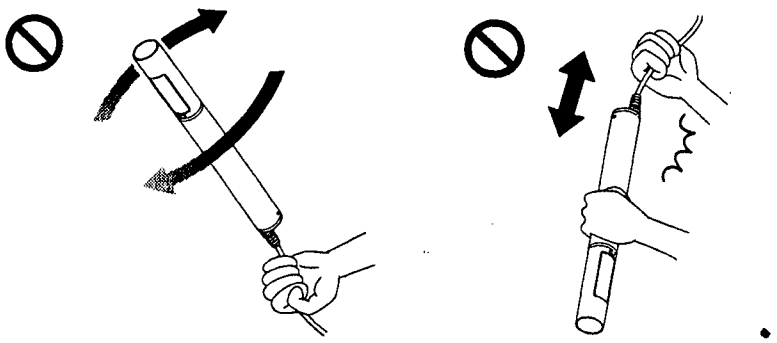


1. Introduction

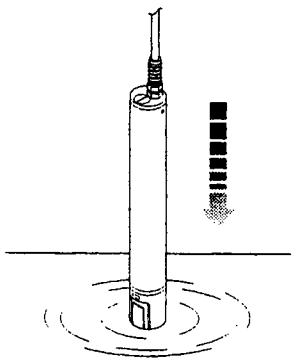
1.1 Notes on handling the instrument

① Handling the sensor

• Do not swing the sensor around or pull the cord on the sensor.



• Slowly lower the sensor probe into the sample.

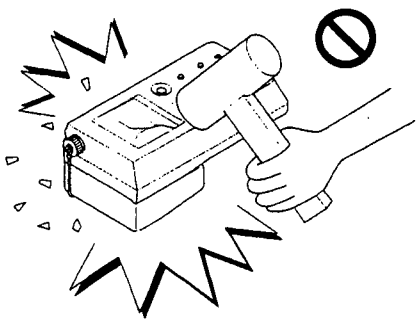


⚠ WARNING

- In place with a large distance to the water level or with a rapid water flow, fix the sensor probe hook to a point except your body before use for safety purposes.
  Be careful not to let go off the sensor probe by mistake. Otherwise, the sensor probe together with the instrument will fall into the water or a sharp shock will occur to yourself while you are holding the instrument.

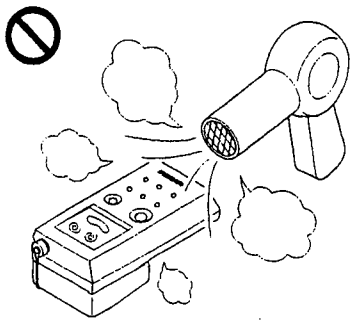
② Shock

• Do not give a shock to or drop the sensor or instrument.

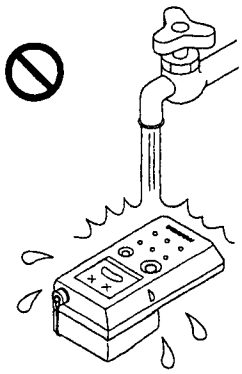


③ Water-proof ability of the instrument

- The instrument will be water-proof in construction (IP-67) when the sensor connector is connected to the instrument. However, if the instrument has been dropped into water or become wet, use a soft cloth to dry up the instrument.
- Do not use a hair dryer to dry up the instrument.

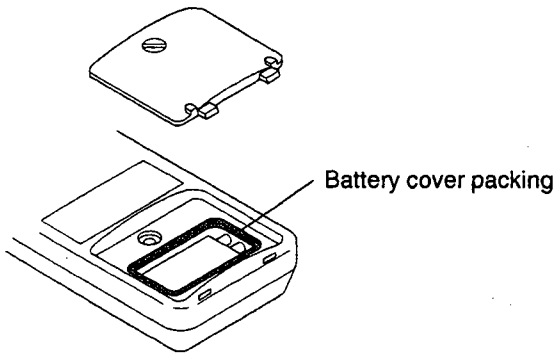


- Do not wash directly the instrument using tap water from the faucet.



④ Opening and closing the instrument battery cover and the expansion unit

- Foreign matter on the battery cover packing can cause water to enter the instrument. Check for foreign matter on the battery cover packing before closing the battery cover and the expansion unit. If the battery cover packing is twisted, do not close the battery cover.



For a long use

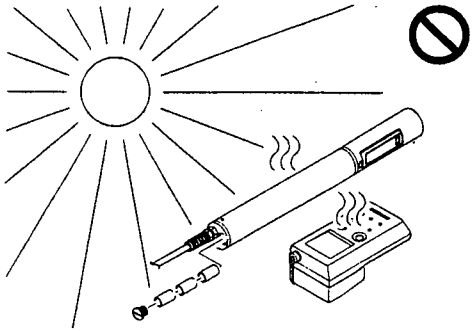
We recommend that the battery cover packing be replaced once a year.
For battery cover packing replacement, contact your sales agent.

⑤ Replacing the sensor probe battery

- Do not replace the sensor probe battery in very hot and wet atmosphere.
- Replace the battery with the instrument connected to the probe.

⑥ No direct sunlight to the instrument

• The display part includes LCD. Do not expose the instrument to ultraviolet rays for a long time. Otherwise, the LCD may deteriorate.



⑦ Chemical resistance

• Do not soak the instrument or sensor in alcohol, organic solvent, strong acid, or strong-alkaline solution.
The instrument includes ABS and acrylic resins and various types of rubber. The sensor part includes polycarbonate resins, denatured PPO resins, polypropylene resins, polysulfone resins, POM resins, nylon resins, and various types of rubber.

For a long use

If the instrument and sensor probe become contaminated, use a soft cloth damped with water or diluted detergent to wipe off the contamination.

⑧ Note on place for use

• Do not use the instrument in the atmosphere with ambient temperatures below 0°C (incl.) or above 55 °C (incl.). Also avoid using the instrument in the atmosphere with sharp vibrations and corrosive gases.
Do not use the instrument near a source of strong electromagnetic field such as high-voltage cables and motors.

⑨ Batteries

The improper use of batteries may cause leaks and explosion.
Observe the followings:

- Set the batteries in place properly while paying attention to the plus (+) and minus (-) poles.
- Do not use both an old and new batteries or batteries of different types.
- Batteries for use in the instrument are not of the rechargeable type.
- Remove the batteries when not in use for a long time.
  In case of leaks, wipe off the solution in the battery case thoroughly and place new batteries in position.

⑩ Do not disassemble the instrument.

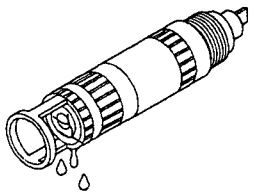
• Never disassemble the instrument. Otherwise, the water-proof performance of the instrument will be impaired.

⑪ Handling the DO sensor

• For any broken DO sensor diaphragm, replace the DO sensor.

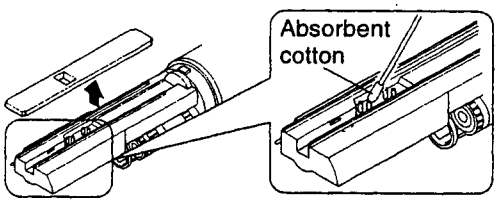
⚠CAUTION

• The DO sensor holds a strong-alkaline solution. Protect the eye and skin from the solution. If there is any solution in the eye or on the skin, immediately use sufficient water to wash off the solution. Consult a doctor as required.



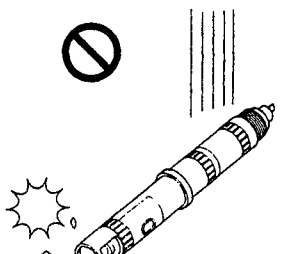
⑫ Handling the COND/TURB unit

• When cleaning the COND/TURB unit, use an absorbent cotton to avoid damage to the TURB cell.



⑬ Handling the pH sensor

• The pH sensor has a glass electrode at the end. Handle the sensor carefully to avoid a break in the glass electrode.



⚠CAUTION

• Be careful not to break the glass on the top of the sensor. Otherwise you may get hurt with a piece of glass.

⑭ Handling the Connector section

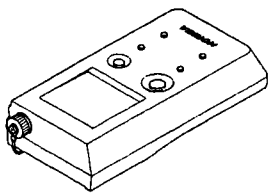
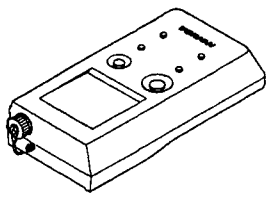
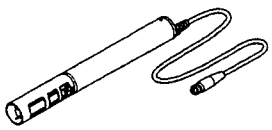
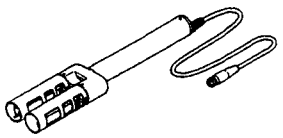
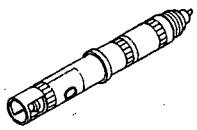
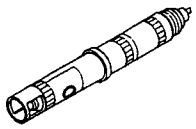
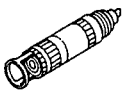
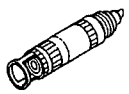
• Handle the sensor connector section carefully to protect it from water, sensor-contained solution, sample and contamination.

⑮ Disposal

• Dispose of this product as industrial waste. Otherwise this may affect the environment.

1.2 Packing list

The U-20 series is comprised of the following items.

Model	U-22	U-23
Meter (U-2000)		
Sensor probe		
Sensor	pH/ORP sensor 	pH/ORP sensor 
	DO (Dissolved-Oxygen) Sensor 	DO (Dissolved-Oxygen) Sensor 
		Ion sensors for selected ions
Accessories	pH4 standard solution (500 ml)	pH4 standard solution (500 ml)
	pH internal solution (250 ml)	Ion one-point standard solution for Cl^-, NO_3^- Ca^{2+} (250 ml) [not include F^-, K^+, NH_3]
		pH internal solution (250 ml)
		Specific internal solutions for selected ions
	pH syringe with needle	pH syringe with needle
		Specific ion syringe for selected ions
		Connector plug for the probe (3 pieces)
	Sensor spanner	Sensor spanner
	Calibration beaker	Calibration beaker (2 pieces)
	Grip holder	Grip holder
	Carrying case	Carrying case
	Manganese battery 6F22 (006P) (1 piece)	Manganese battery 6F22 (006P) (1 piece)
	Alkaline batteries LR03 (AAA) (3 pieces)	Alkaline batteries LR03 (AAA) (3 pieces)
	Operation manual	Operation manual

- The included battery is for the monitor. Its life is not guaranteed.

2. Before Use

2.1 Introduction to the U-20 series models

2.1.1 Measurement items

Components that can be measured with the U-20 series models are as follows:

Model	U-22	U-23
Measurement items		
pH	○	○
Dissolved Oxygen (DO)	○	○
Conductivity (COND)	○	○
Salinity (SAL) [Conductivity conversion]	○	○
Total dissolved solids (TDS) [Conductivity conversion]	○	○
Specific gravity of seawater [Conductivity conversion]	○	○
Temperature (TEMP)	○	○
Turbidity (TURB)	○	○
Water depth (DEP)	○	○
Oxidation-Reduction Potential (ORP)	○	○
Chloride ion Cl^-	–	○ *
Nitric acid ion NO_3^-	–	○ *
Calcium Ca^{2+}	–	○ *
Fluoride ion F^-	–	○ *
Kalium ion K^+	–	○ *
Ammonia gas NH_3	–	○ *

○ ..... Measurable

* Selected ion items

2.1.2 Introduction to functions of the instrument

Outline of the functions of the instrument is described below.

Feature	Function name	Page
Data obtained during measurement can be saved in the memory.	Manual data storage	Page 34
Data can be automatically saved in the memory at constant time intervals.	Auto data storage	Page 36
Saved data can be called.	DATA OUT	Page 41
The latest date of calibration and its details can be called.	Calibration history	Page 43
Enlarged display is available.	Expand readout	Page 65
Measurement units can be switched.	Switching measurement unit	Page 66

* Other functions possible in the check mode are available. (☞ Page 76)

2.1.3 Functions of expansion units

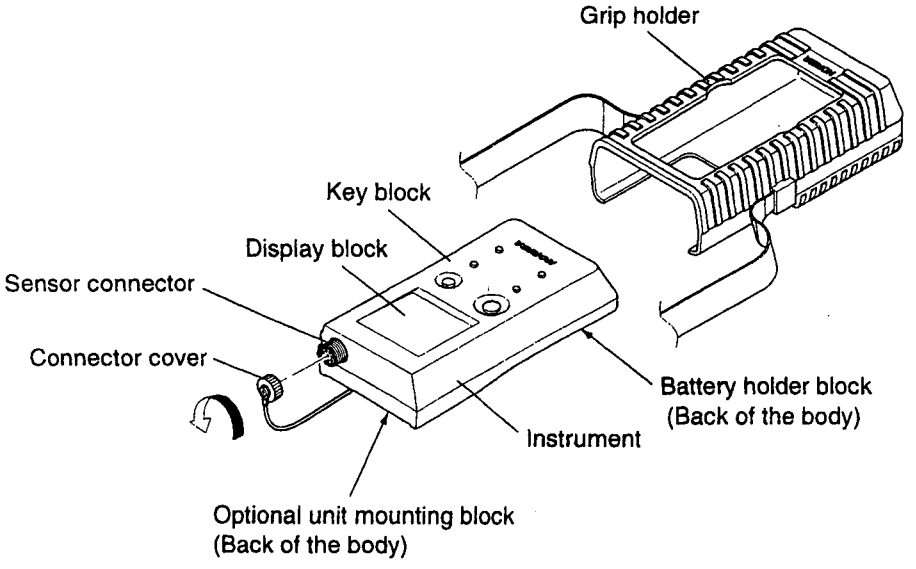
For the U-20 series, use of expansion units allows communications with personal computers through RS-232C, the storage of G.P.S. data in the memory, and printer output, and commercial power supply.
Expansion units are available in the following two types:

Unit/name	Contents	Functions
U-2001	• Expansion adaptor	<RS-232C communications, G.P.S connection, and printer output>
Expansion adaptor	• Software for PC	The above functions cannot be used at the same time. One of the connectors for these three functions needs to be used.
U-2002	• System unit contain case	<RS-232C communications, G.P.S connection, printer output, battery power supply*>
System unit	• Software for PC	The above functions can be used at the same time.
	• G.P.S. unit	* A battery power supply can be used for measurements outdoors for 30 consecutive days.
	• Printer set	

* U-2001 and U-2002 can operate on a commercial power supply through the use of an AC adapter (optional). However, the AC adapter cannot be used for the G.P.S. unit or printer set.

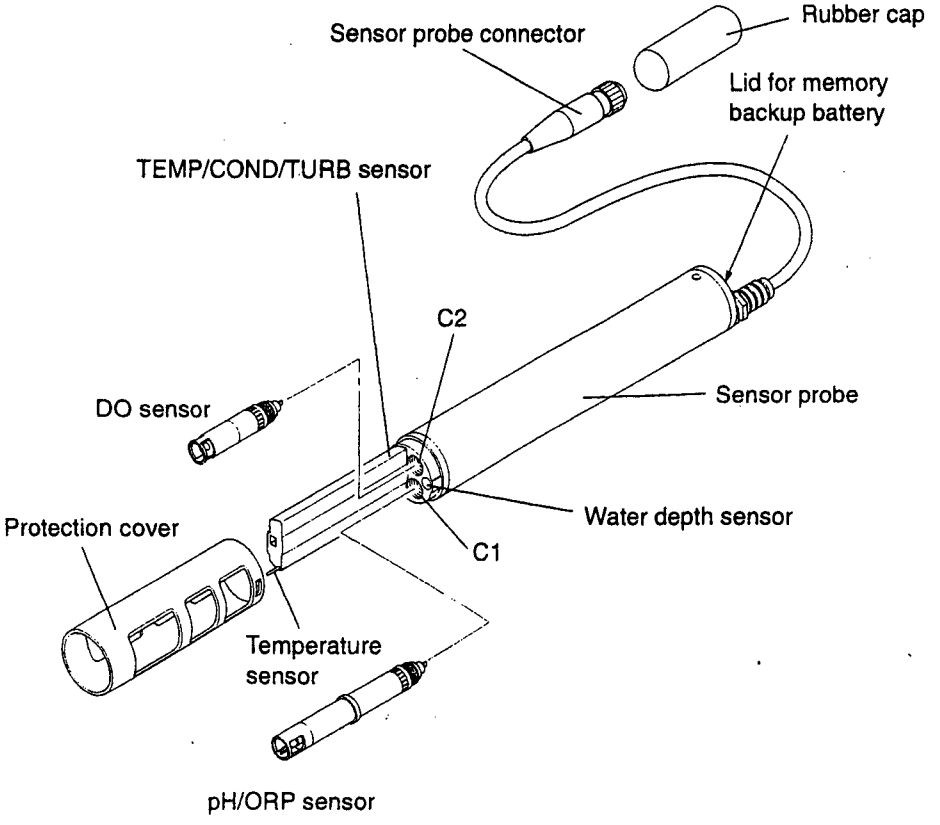
2.2 Names of the parts

2.2.1 Instrument name

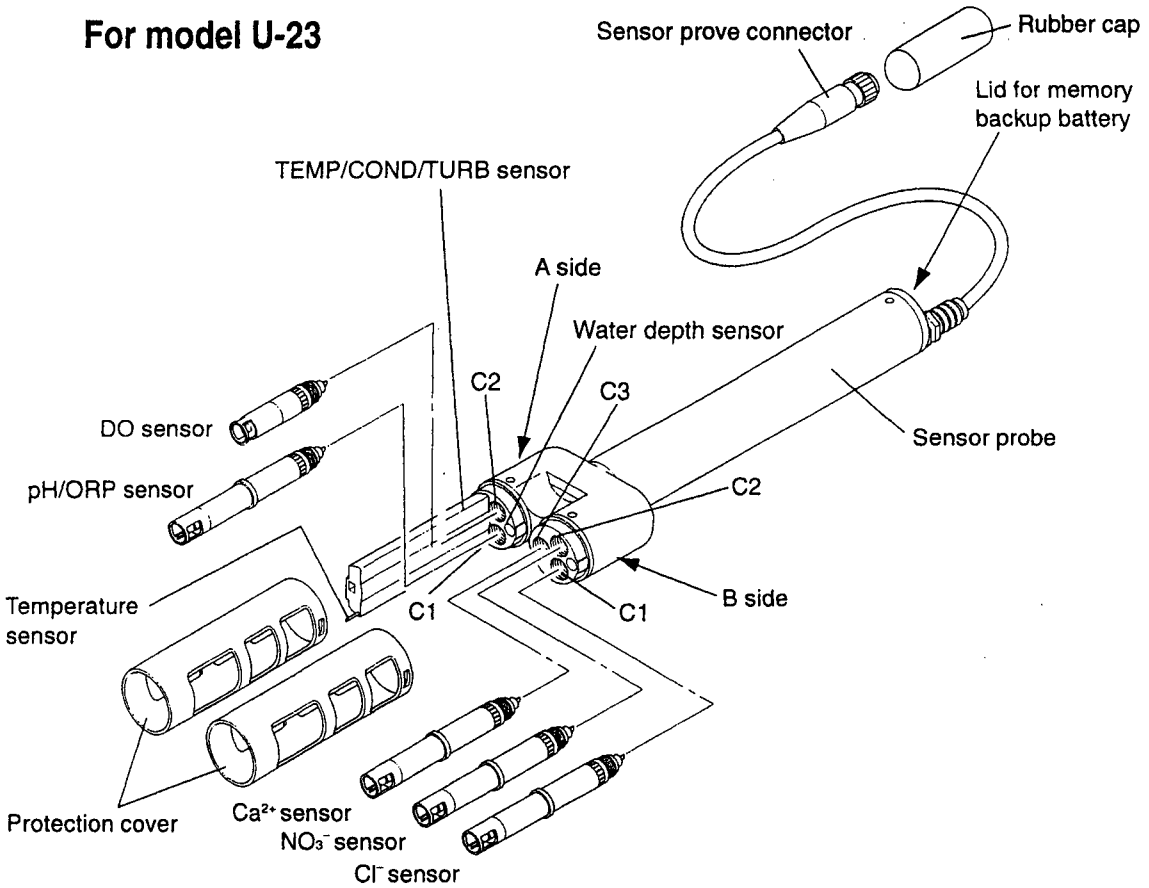


2.2.2 Sensor probe names

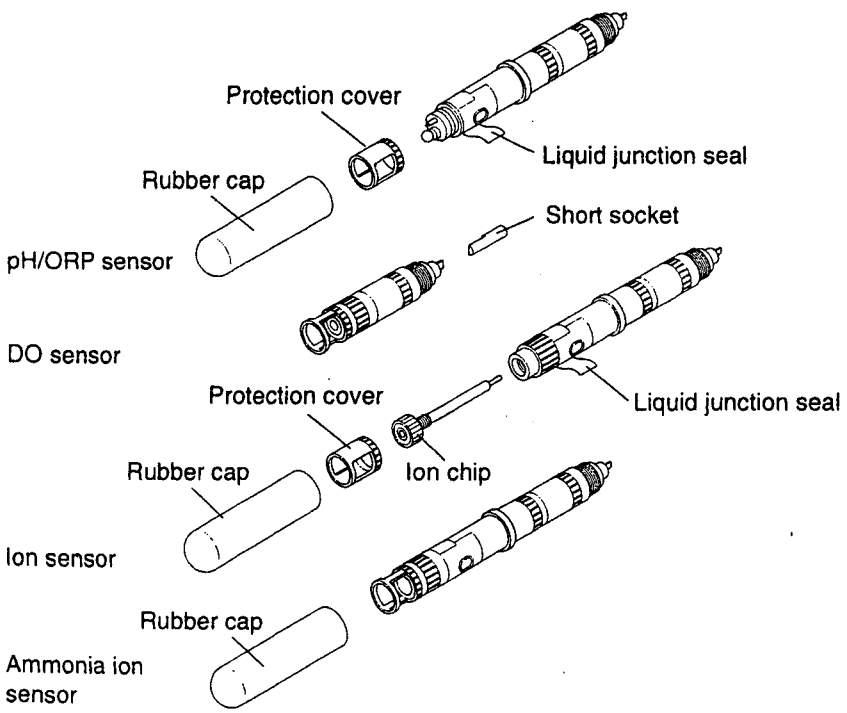
For model U- 22



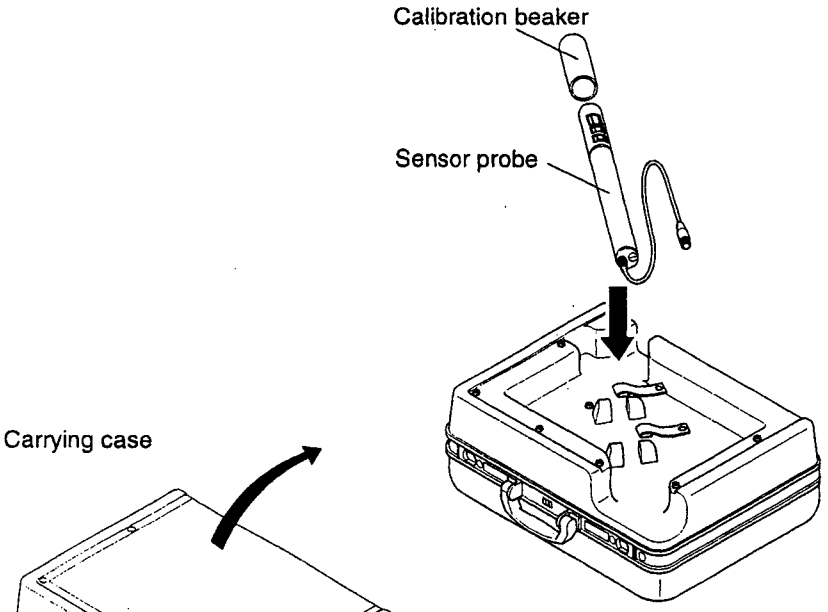
For model U-23



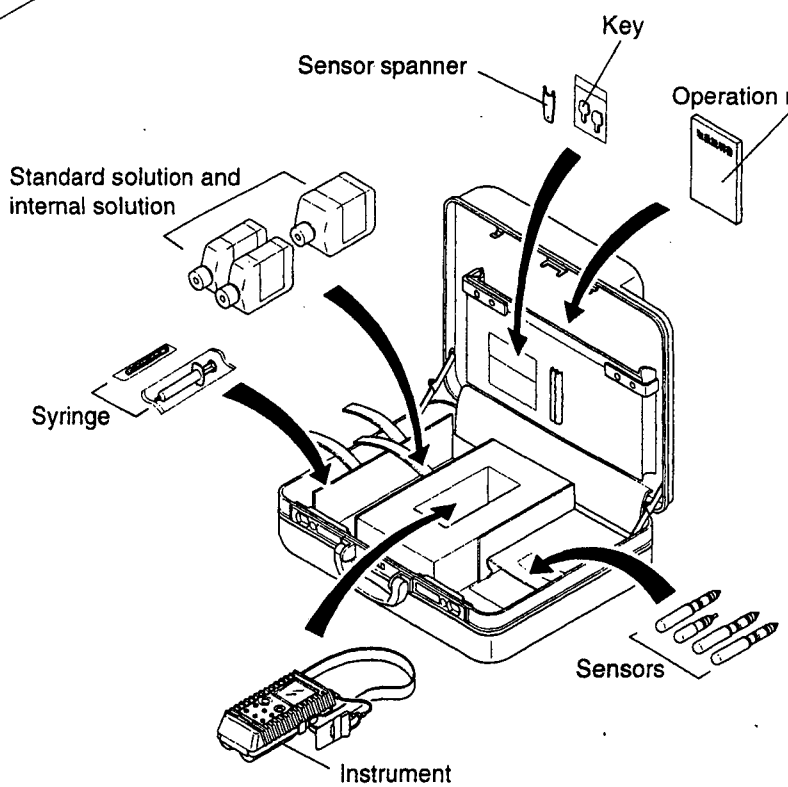
2.2.3 Sensor names



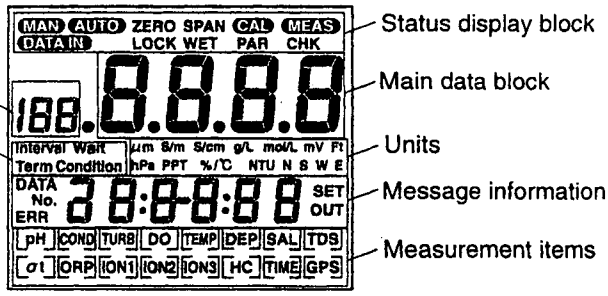
2.2.4 Use of carrying case



(Storage of a cable 10 m or less long.)



2.2.5 Display



Status display block

MAN ..... On when the data memory and calibration settings are set to manual.
AUTO ..... On when the data memory and calibration settings are set to automatic.
DATA IN ..... On when the data memory operation and the data memorys operation settings are being performed. Blinking during calibration.
ZERO ..... On in the Zero calibration mode.
SPAN ..... On in the Span calibration mode.
CAL ..... On in the Calibration mode.
MEAS ..... On in the Measurement mode. (Measurements are being made when light up.)
LOCK ..... On when the keys are locked.
CHK ..... On when the instrument is in the check mode.

Sub data block

Display of the pH, Latitude (degree), Longitude (degree), Year and Check No.

Main data block

Display of Measurement data. Latitude (minute, 〔second〕), Longitude (minute, 〔second〕), and month and day.

Data storage conditions setting

Interval ..... On when a time interval is set for storage of data.
Wait ..... On when a time is set for waiting from the automatic data storage instruction until the start and during data processing through individual operations.
Term ..... On when a period is set for automatic data storage.

Units

Displays the units for measurement items.

Message information

Displays the stored data (data mode) and the data No. when the data is stored.
SET ..... Indicates that the instrument is in Set mode.

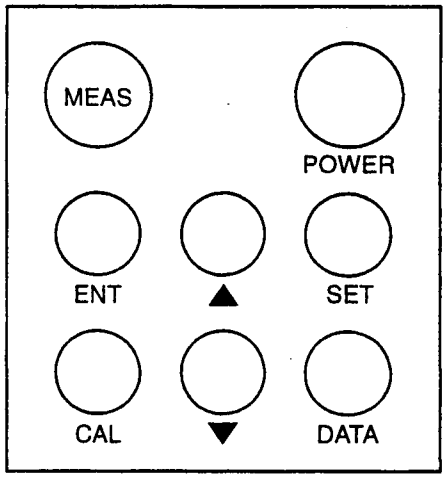
Measurement items

Displays the measurement items for the data in the main data block display. The display is read as follows.
Items without brackets ([ ]) ..... Items with the highlighted text will be stored in the data memory.
(☞ *Measurement item setting*, page 79)
Items with brackets ([ ]) ..... Displays the measurement items with data display.
(☞ *Measurement item setting*, page 79)

Note

- Because of the instrument's automatic power off function, the indication will disappear if the unit is not used for about 30 minutes. For operation of the unit and display of the indication, turn ON the instrument again.

2.2.6 Key names



POWER: Power key

Turns the instrument On and Off. Immediately after the power is switched on, the initial screen is displayed to indicate the status of the instrument.

MEAS: Measurement key

In the Measurement mode (MEAS is on), this key switches the measurement item. In addition, pressing the MEAS key returns you from the Setting, Calibration and Memory Call Up modes to the Measurement mode.

Note

- Regardless of which mode the instrument is in, it is always possible to return to the Measurement mode by pressing the MEAS key.

ENT: Enter key

In the Measurement mode (MEAS is on), pressing the ENT key stores the data in memory.
In the Calibration mode (CAL is on), pressing the ENT key performs calibration.
In the Setting mode, pressing the ENT key switches the setting and registers entered setting values.

CAL: Calibration key

Pressing the CAL key switches the instrument to the Calibration mode. If automatic data storage is in progress, it is aborted.

SET: Set key

Pressing the SET key switches the instrument from the Measurement mode to the Set mode. If the SET key is pressed on the "year, month, day, time" display screen, it switches the instrument to the Check mode.

DATA: DATA key

Pressing the DATA key switches the instrument to the Data mode.

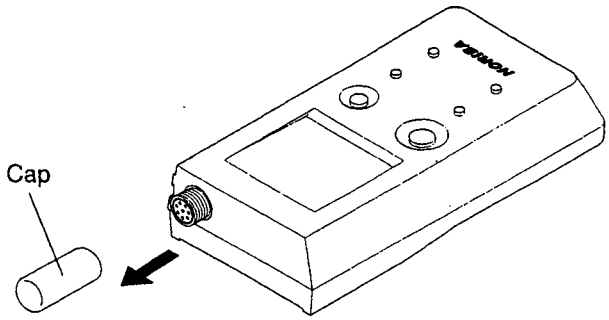
▲▼ : UP/DOWN keys

Use the UP/DOWN (▲▼) keys to set the calibration value in the Manual mode.

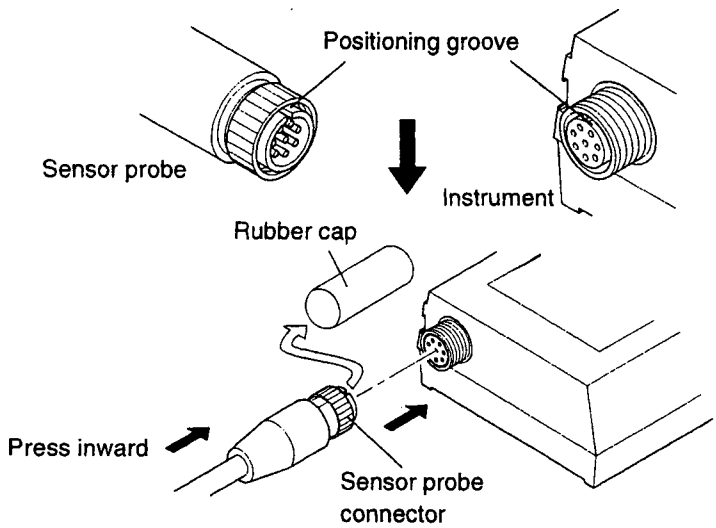
2.3 Setting up the U-20 series models

2.3.1 Instrument and sensor probe connection

1. Remove the cap from the instrument's connector.



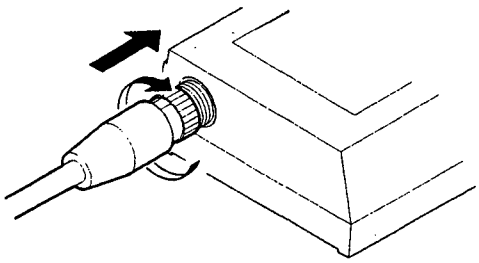
2. Align the positioning grooves of the instrument's connector and sensor probe connectors, and fit the connector of the sensor probe into the this other.

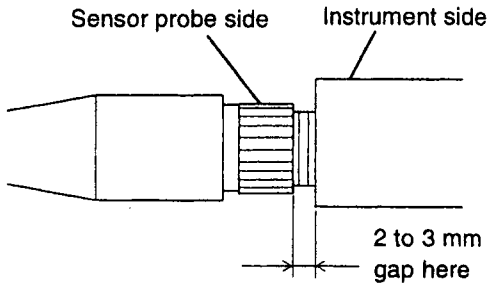


3. Press the sensor probe connector inward and turn. Tighten the connector until it will not turn any more.

Important

- Unless snugly attached, the instrument is not fully waterproof. When the sensor probe connector is tightened as far as it can go, a 2 to 3 mm gap is left between the instrument's connector and sensor probe connector.





Note

- Tighten the sensor probe connector until it will not turn any more.

⚠ CAUTION

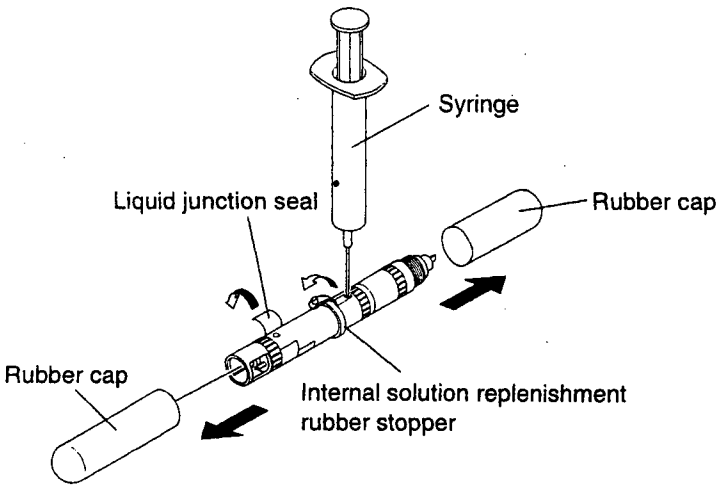
- The connector cover or sensor probe connector should be connected to the instrument. Otherwise, the instrument will not be waterproof.

2.3.2 Sensor installation

Connect the Dissolved Oxygen (DO), pH and ion (Cl^-, No_3^-, Ca^{2+}) sensor to the sensor probe.

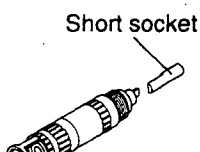
Preparing pH (pH/ORP) sensor

1. Remove the liquid junction seal and rubber caps.
2. Open the internal solution replenishment rubber stopper. Then use a syringe to take internal solution (#330).
   Air bubbles in the internal solution may impair the pressure compensation of the sensor. Allow as few air bubbles as possible to enter the inside solution.



Preparing DO sensor

1. Remove the short socket.



Important

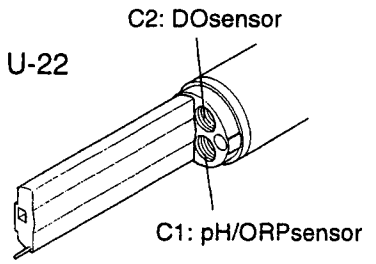
- Provide the DO sensor with a short socket or connect the sensor to the sensor probe for storage. Otherwise, stable instructions may not be obtained.
- The short socket is used when storing. Do not throw it away.

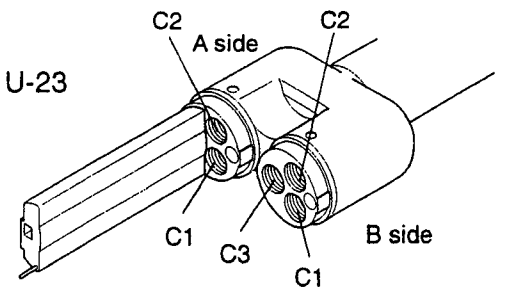
Where to attach

1. The hole on the sensor probe in which each sensor is attached is determined by the type of sensor. Check the type of sensor and the assigned hole before attaching anything.

Important

- Be sure to connect the standard attachment ion sensor to the sensor probe as illustrated. Otherwise, the automatic calibration function would not work.
- Installing the sensor in the wrong hole will damage both the sensor and sensor probe.
- A specific hole, C1 to C3, is not specified for other ion sensors.





A side C1: pH/ORP sensor
C2: DO sensor

B side C1: Cl^- sensor
C2: NO_3^- sensor
C3: Ca^{2+} sensor

Important

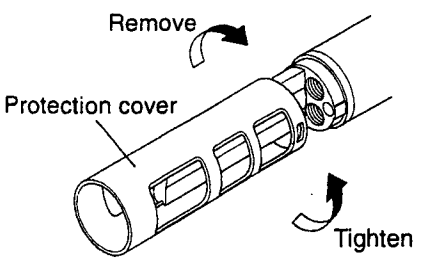
- When the optional ion sensors are connected to the sensor probe, C1 to C3 will be indicated as below. ION1 → C1, ION2 → C2, ION3 → C3

Installation procedure

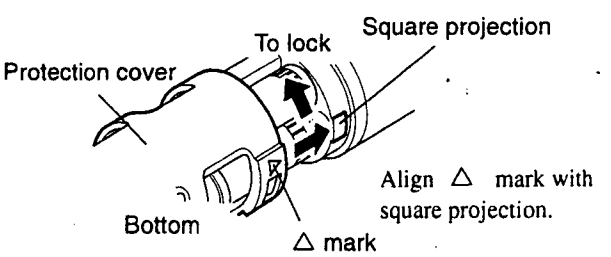
Important

- With the U-22 sensor probes and U-23 side A sensor probe, install the DO sensor first and then the pH sensor (pH/ORP sensor). With U-23 side B, install the C3 sensor first; otherwise, installation is as explained herein.

1. Remove the calibration beaker and remove the protection cover from the sensor probe.



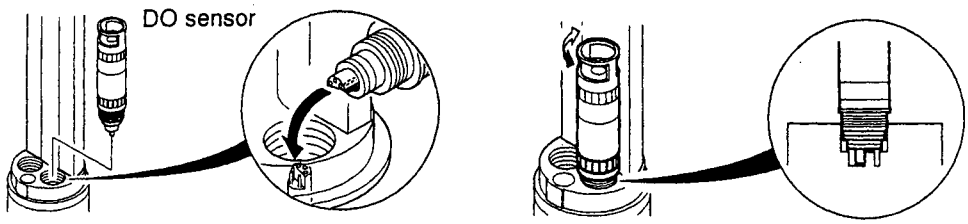
Looking from below, the protection cover is locked by turning it counter-clockwise and removed by turning it clockwise.



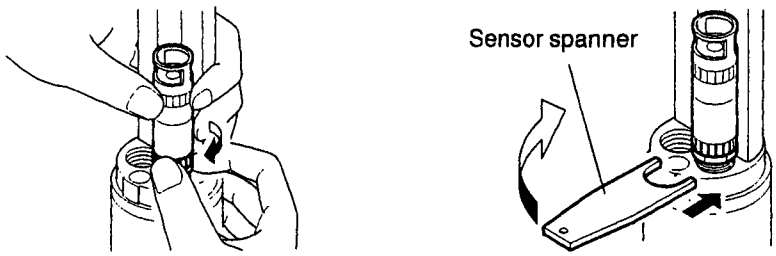
2. Fit the DO sensor inside the sensor probe hole, being careful to align the shape of the connectors.

Important

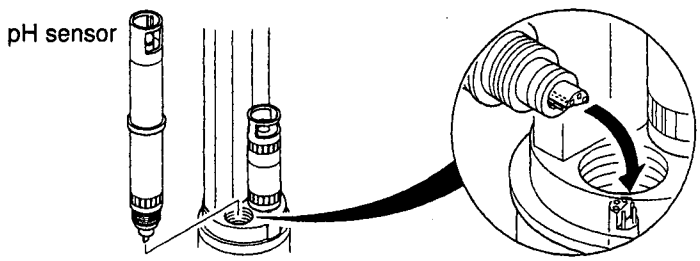
- Press the sensor slightly inward and try turning to check the fit. The sensor cannot be turned if inserted properly.



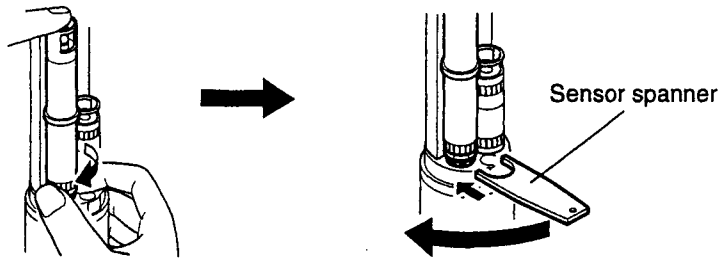
3. Turn the screw 2 or 3 turns by hand and then fully tighten with the sensor spanner.



4. Fit the pH sensor inside the sensor probe hole, being careful to align the shape of connectors.



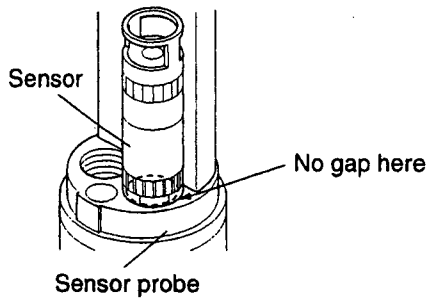
5. Holding the top of the pH sensor with your finger, turn the screw 2 or 3 turns by hand and then fully tighten with the sensor spanner.



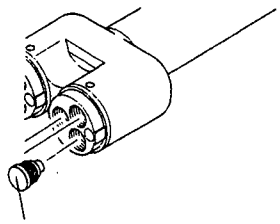
⚠ CAUTION

- Unless snugly attached, the sensor is not fully waterproof. The sensor is snugly fit inside the sensor probe when tightened as far as it will go.

Example for DO sensor



- If any of the sensors is not used, be sure to attach a connector plug for the probe to the opening for the relevant sensor probe instead of the sensor. Otherwise, the sensor probe will not be waterproof.



6. Attach the removed protection cover to the sensor probe as it was.

Important

- Before attaching each sensor to the sensor probe, do not soak the connector block in water.
- Be careful not to contaminate or wet the sensor probe or sensor connector.

2.3.3 Installation and replacement of the battery

The U-20 series is shipped from the factory with the battery packed separately.
When using the instrument for the first time or replacing the battery, perform the following procedure:

Type of battery:

Instrument (U-2000) ..... Alkaline battery 6LR61 (Manganese battery 6F22 [006P])
1 piece. (Battery for instrument operation)
Sensor probe ..... Alkaline batteries LR03 [AAA] (Manganese battery [R03])
3 pieces. (Battery for memory backup)

Notes on handling the battery

The improper use of battteries may cause leaks and explosion.
Observe the followings:

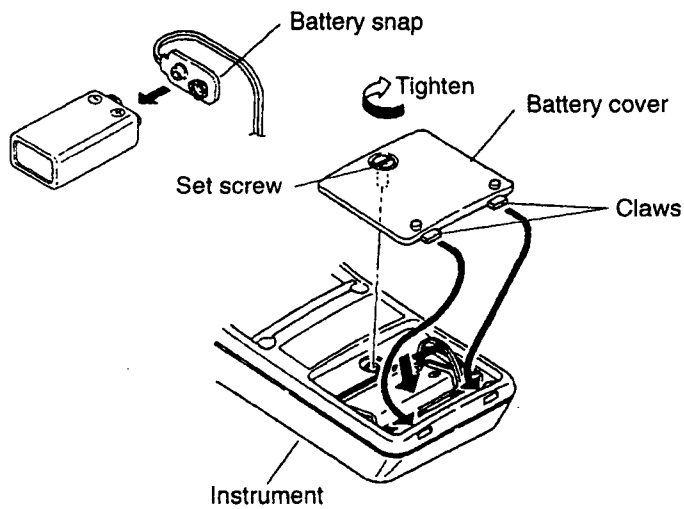
- Set the batteries in place properly while paying attention to the plus (+) and minus (-) poles.
- Do not use both an old and new batteries at a time or batteries of different types.
- Battteries for use in the instrument are not of the rechargeable type.
- Remove the batteries when not in use for a long.
  In case of leaks, wipe off the solution in the battery case thoroughly and place new battteries in position.

Note

- The battery originally attached to your unit is for monitor and the service life of the battery cannot be guaranteed.

Instrument (U-2000)

1. Loosen the set-screw on the battery cover and remove the cover.
2. Remove any old battery.
3. Fit the battery snaps to a new battery and insert the battery assembly into the instrument.
4. Insert the claws on the battery cover into the grooves in the instrument. Then tighten the set screw.
   The battery snap may be loose for some batteries. In such a case use radio pliers and tighten the metal snap fittings.

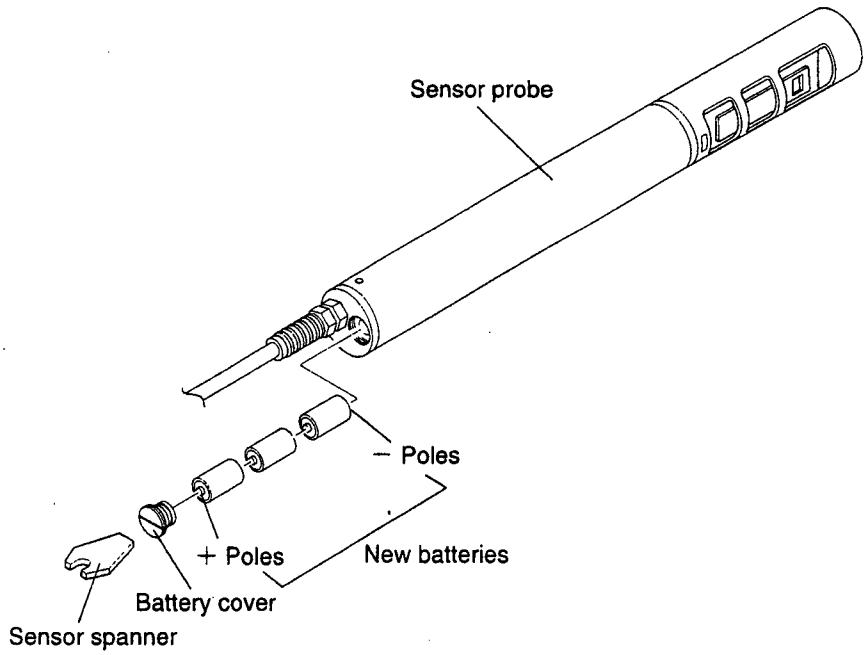


Important

- When removing the battery snap, do not pull it too strongly.

Sensor probe (for memory back up)

1. Remove the battery cover using a sensor spanner or a suitable object.
2. Remove any old batteries.
3. Insert new batteries making sure that the plus (+) and minus (-) poles match the terminals correctly.
4. To keep the sensor probe water-resistant, use a chip spanner as illustrated below and tighten the battery cover until the cover does not turn any more.



⚠ CAUTION

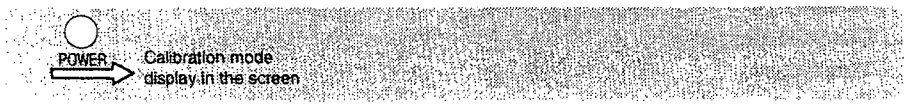
- When replacing the batteries of the sensor probe, be sure to connect the sensor probe to the instrument. Otherwise, the memory will be reset and all the data saved in the memory will disappear.

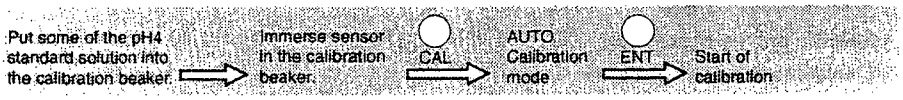
◖Note◗

- The battery on the main unit is used up first allowing up to 30 hours use at room temperature. (When using alkaline batteries.)
- Life is reduced by approximately one half when manganese batteries are used.

3. Basic operation

The pH, conductivity (COND), turbidity (TURB), dissolved-oxygen (DO), water depth (DEP) and ion (ION1, 2, 3) sensors can be calibrated automatically. Upon completion of this chapter, even beginners should be able to make measurements easily.



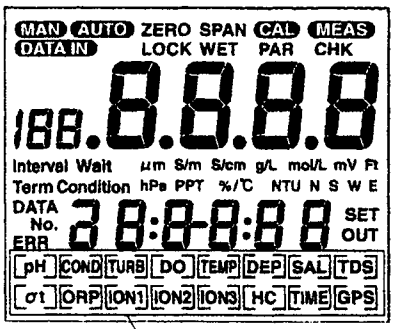


3.1 Key operations and mode switching

Measuring items and displays which are switched with the MEAS key

The items measurable with individual models are displayed. The items selected with the MEAS key will be indicated with [ ].

Example: In the pH Measurement mode: [pH]



Display block

The symbols displayed and their meanings are as follows:

pH ..... pH
COND ..... Conductivity
TURB ..... Turbidity
DO ..... Dissolved-Oxygen
TEMP ..... Temperature
DEP ..... Depth
SAL ..... Salinity
TDS ..... Total dissolved solids
σ_t ..... Specific gravity of seawater
ORP ..... Oxidation-reduction potential
ION1 ..... Cl^- (Chloride) ion
ION2 ..... NO_3^- (Nitric acid) ion
ION3 ..... Ca^{2+} (Calcium) ion
} if standard attachment ion sensors are used
TIME ..... Display of date and time
GPS ..... G.P.S. (Global Positioning System) for imformation of position

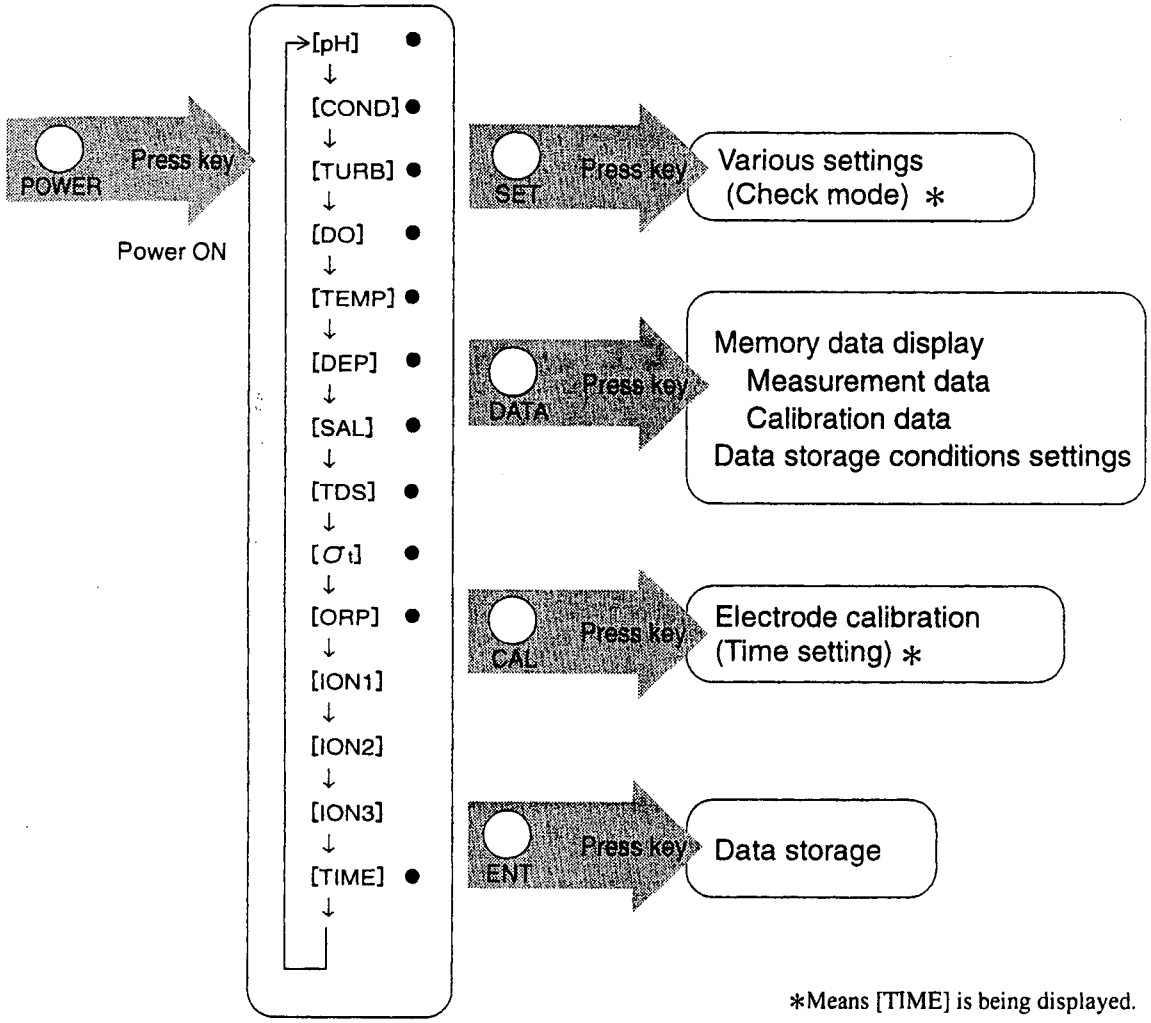
* When optional sensors Cl, C2, and C3 are connected to the instrument, ION1, ION2, and ION3 appears for the optional sensors Cl, C2, and C3, respectively.

Note

- [GPS] lights up when the optional G.P.S. sensor has been connected to the instrument and position information is received from the G.P.S. sensor during the measurement. For more information, refer to the instruction manual for the expansion units.

U-23 Measurement mode

MEAS When the MEAS key is pressed, the next measurement item appears.



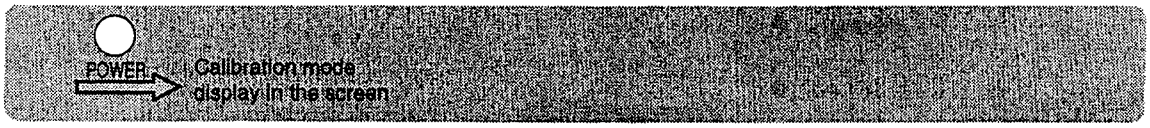
*Means [TIME] is being displayed.

Note

- The measurement items for the U-22 model are indicated with ●, respectively.
- "*Measurement item setting*" on page 79 explains how to set the display so items are not displayed.

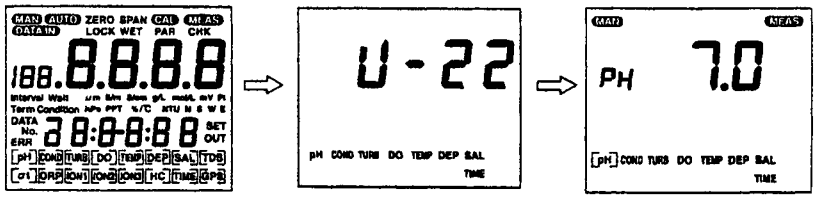
3.2 Operation procedure

3.2.1 Power ON



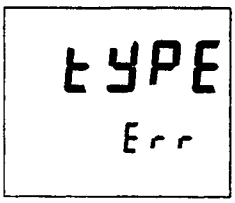
1. Press the **POWER** key.

The display will change in the order of All segment display → Sensor detector display → pH Measurement mode.



For U-22 model

With the sensor probe is not connected,



is displayed.

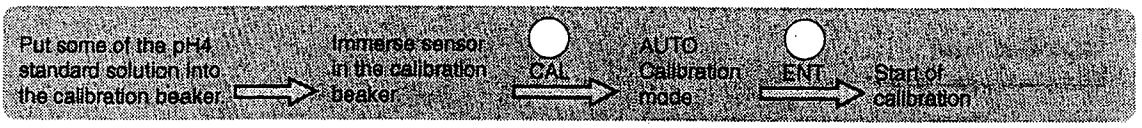
Before turning ON the instrument, connect the sensor probe properly.

3.2.2 AUTO calibration method

To obtain correct measurement, it is necessary to calibrate the sensor using the standard solution before performing measurement.

Note

- In the AUTO calibration mode, the pH, COND, and TURB sensors are calibrated in the pH4 standard solution, and the DO and DEP sensors in the atmosphere simultaneously.
- Values may be unstable if there is temperature fluctuation. Calibrate after waiting for about an hour.

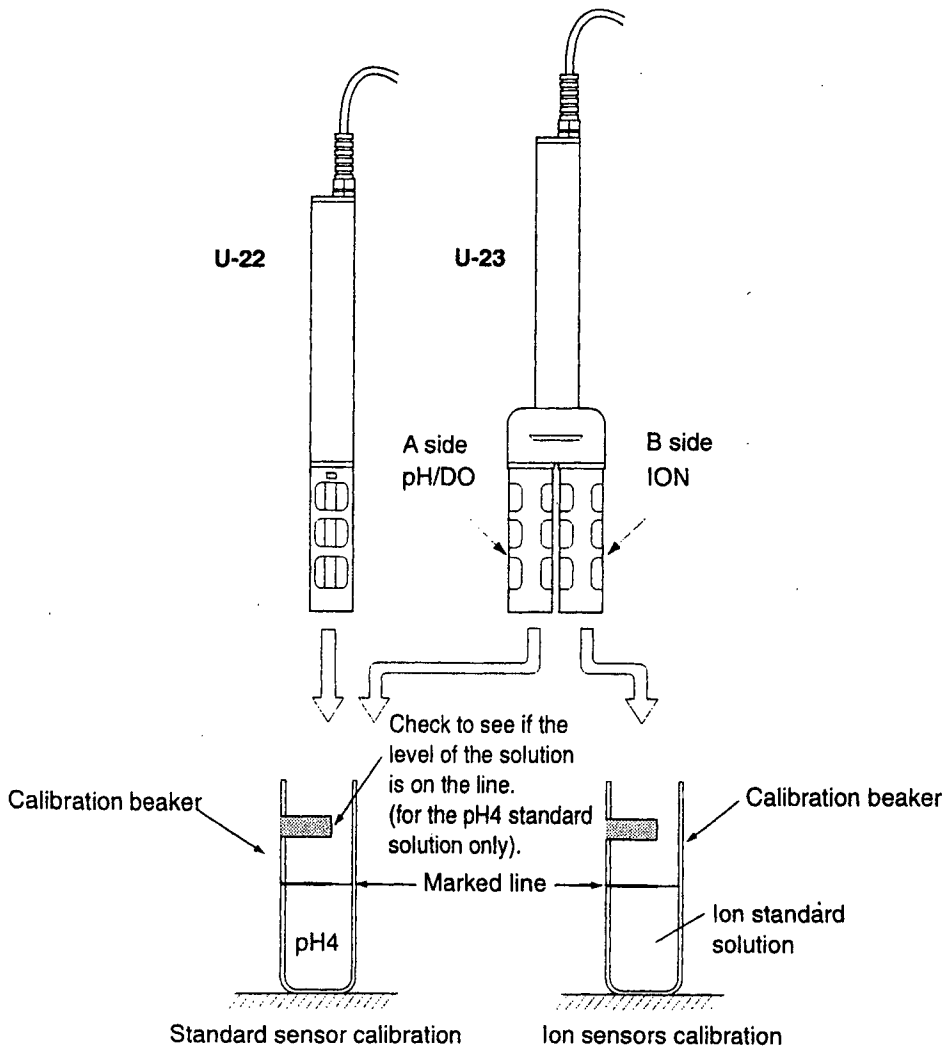


Calibrate using the following procedure.

1. Wash the sensor in distilled water a few times and put some of the pH4 standard solution into the calibration beaker to the marked line. Then immerse the sensor in it.
For the U-23 model, immerse the sensor A side.

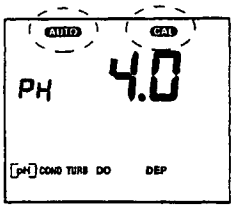
Important

- Use the label on the calibration beaker and check to see if the level of the calibration solution is on the label line.



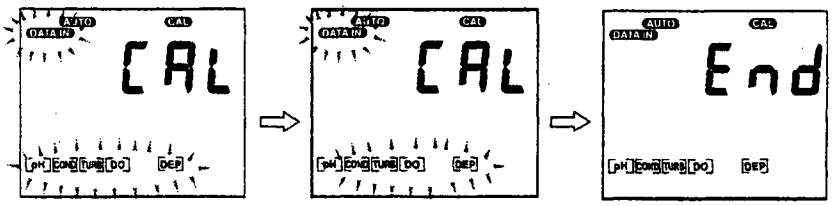
2. Press the **CAL** key in one of the Measurement modes pH, COND, TURB, DO and DEP.

AUTO and **CAL** appear and the instrument enters the AUTO Calibration mode.



3. Press the **ENT** key to start AUTO Calibration.

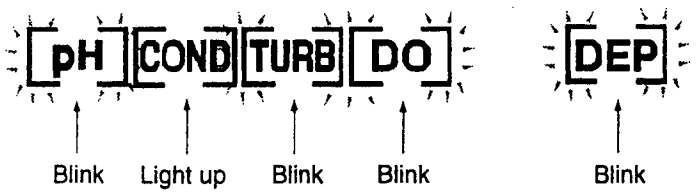
Upon completion of all of the pH, COND, TURB, DO, and DEP modes, **End** will be displayed.
During calibration, **DATA IN** and [ ] for the selected measurement item blink. [ ] light up for the item of which calibration is finished.



End of calibration

With DATA IN is blinking
To stop calibrating the sensor .... press the CAL key.
To establish the calibration ..... press the ENT key.

Example: When COND calibration is finished:
[ ] for [COND] stops blinking and light up steadily.



Note

- [ ] continues to blink because calibration is not performed for the item for which an error has happened. If two or more errors happen, an error with a smaller number appears. (See pages 89 to 91 for these errors and ways to solve them.) These calibration errors disappear when the sensor is calibrated properly again, or when the instrument is turned ON again.
- Calibration should be performed for maximum three minutes. When the indications become stable, calibration should be finished.

4. Press the **MEAS** key to return to the Measurement mode.

Important

- Neutralize any basic pH 4 fluids before disposal.

AUTO calibration of the ion sensors (U-23 model only)

AUTO calibration of the ion sensors (only for the combination of Cl^-, NO_3^-, Ca^{2+}).
The AUTO calibration function can be performed if the user has selected the combination of Cl^-, NO_3^-, Ca^{2+} ion sensors. For other combination of the ion sensors, be sure to set the ion valency described on page 74 for the manual calibration.

Important

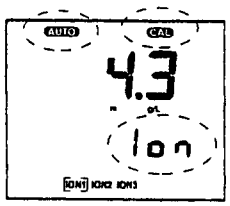
- Ion sensors take time to give stable indications. Therefore, immerse the ion sensors in the sample for approximately one hour. Then calibrate the ion sensors and perfom measurements.

1. Wash the sensor in distilled water a few times and put some of the supplied ion standard solution (#130) into the calibration beaker to the marked line. Then immerse the B side of the sensor in it.

2. Enter ion measurement mode 1, 2 or 3.

3. Press the **CAL** key.

AUTO, **CAL**, and "Ion" below them appear. The instrument then enters the AUTO Calibration mode.

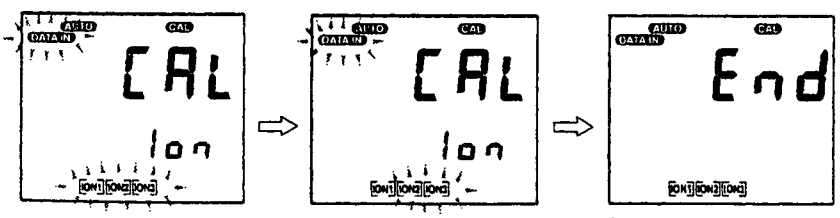


Important

- Only the standard supplied ion sensors (Cl^-, NO_3^-, and Ca^{2+}) can be calibrated automatically in the supplied ion standard solution (#130).

4. Press the **ENT** key to start AUTO calibration.

Upon completion of the AUTO calibration of all the ion sensors ION1, ION2, and ION3, End will be displayed.



End of calibration

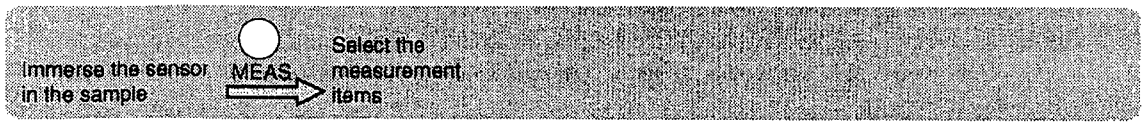
With DATA IN is blinking
To stop calibrating the sensor .... press the CAL key.
To establish the calibration ..... press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

Important

- When the AUTO calibration is performed on the ion sensors, the data for the ion sensor calibrated manually is erased.

3.2.3 Measurement



1. Immerse the sensor in the sample.
2. Select the measurement item.

   Use the MEAS key to switch measurement items in the following order:

   For model U-22

   pH → COND → TURB → DO → TEMP → DEP → SAL → TDS → σ_t → ORP → TIME ... then back to pH.

   For model U-23

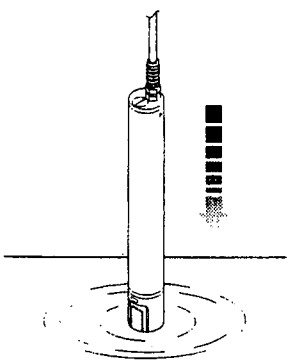
   pH → COND → TURB → DO → TEMP → DEP → SAL → TDS → σ_t → ORP → ION1 → ION2 → ION3 → TIME ... then back to pH.

Note

- [GPS] lights up when the optional G.P.S. sensor is connected to the instrument and position information is received from the G.P.S. sensor.
- The above measurement items can be changed by setting "*Measurement item setting*" described on page 79.

Important

- When immersing the sensor probe in the sample, slowly lower the sensor probe into the sample.



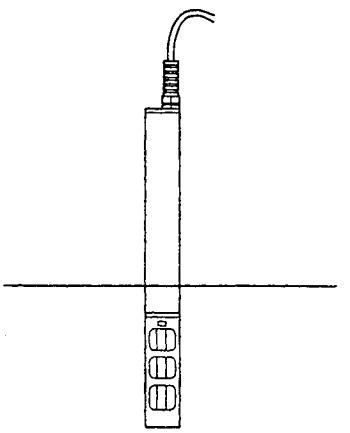
Two useful uses of the U-20 Series models

Making measurements

1. Manually storing the measurement data after checking the indication becomes stable

Example: After switching measurement items with the MEAS key, you can then store the measurement data after checking the indication becomes stable.

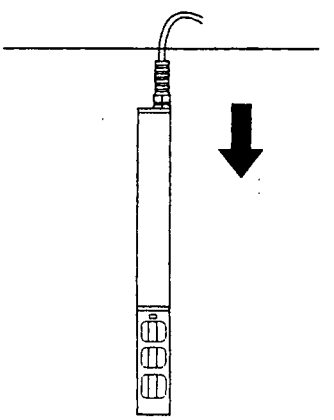
(☞ 4.1 *Manual storage of data while monitoring the measurement data*, page 34.)



2. Storing data

Example: Data can be stored continuously at constant intervals from the start of the automatic data storage. This function is useful in obtaining data in depth direction and in storing data continuously.

(☞ 4.2 *Automatic data storage*, page 36.)



Notes in obtaining data on depth

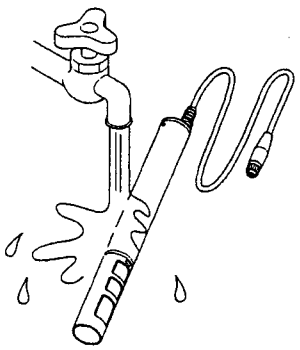
- When the instrument is placed at a depth of 100 m or more, the instrument may be broken. In measurements on the model U-23, the Ca^{2+} and NH_4^+ ion sensors can be used only at depth up to 15 m, and the K^+ ion sensor only at depth up to 3 m. This is because of the properties of the responsive membrane.

Notes for reliable measurements

- Any sensor contamination may affect measurements. Use the AUTO calibration mode to check for contamination on sensors about once a day for ion measurements and about once a week for others.

3.2.4 After completion of measurement

1. Turn the power to the instrument off.
2. Use tap water to completely wash off the sample on the sensor and then wipe waterdrops.



3. Put distilled water into the calibration beaker to the marked line with distilled water. Then, attach the calibration beaker to the sensor probe, cover the connector with the rubber cap and store the probe assembly in the carrying case.

Important

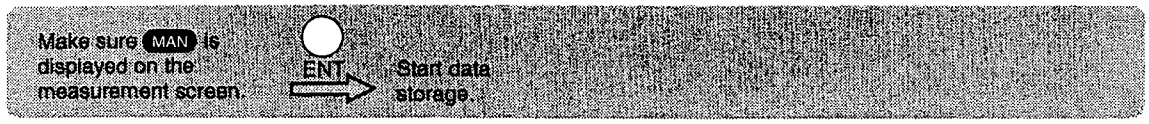
- Do not put water in the calibration beaker before attaching it to the ion sensor end (B side) of U-23.

Now you have read the description for performing measurements. For further information on how to use the instrument, refer to the chapters hereafter.

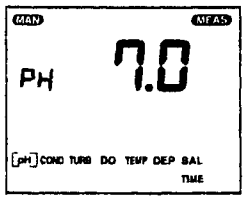
4. Using the data memory function

The data memory function can be used to store manualy measurement values with associated data numbers and to store automatically measurement values at fixed intervals (data logger).

4.1 Manual storage of data while monitoring the measurement data

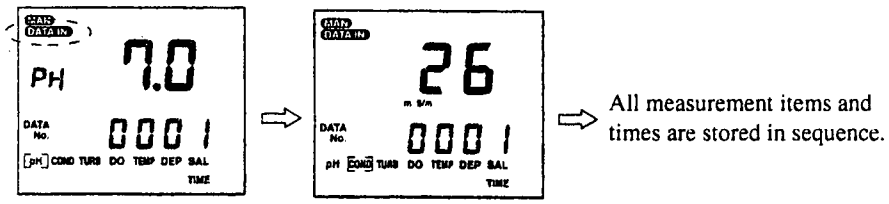


1. Make sure that **MAN** is displayed on the Measurement mode.



2. Press the **ENT** key.

Data storage starts, **DATA IN** and the data No. are displayed on the screen, and the measured value to be stored and the measurement item are displayed in order at approximately 0.5 second intervals.



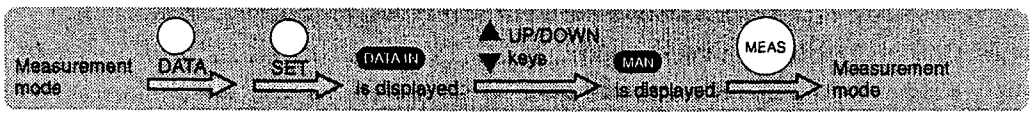
All measurement items and times are stored in sequence.

After the data is stored in memory, the screen returns to the original Measurement mode.

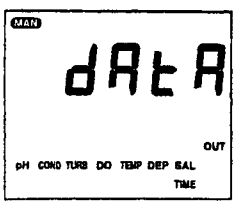
Note

- Up to 2880 sets of data can be stored in the memory.
  When 2880 sets of data have been stored in the memory, ERR 9 appears and no more data can be stored. In this case, "*Data memory clear*" while referring to page 81, and you can store new data in the memory.

- If **MAN** is not displayed (**AUTO** is displayed) in the Measurement mode.

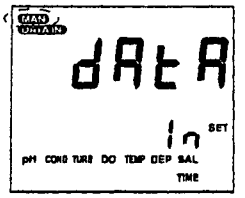


(1) Press the **DATA** key in the Measurement mode.



(2) Press the **SET** key.
DATA IN is displayed.

(3) Press the **UP/DOWN** (▲ ▼) keys to display MAN.

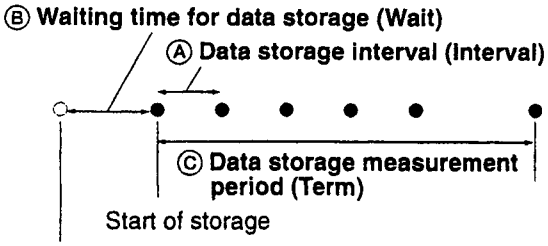


(4) Press the **MEAS** key to return to the Measurement mode.

4.2 Automatic data storage

Measured values are stored automatically at constant time intervals. Before using the automatic storage, the following condition settings are required:

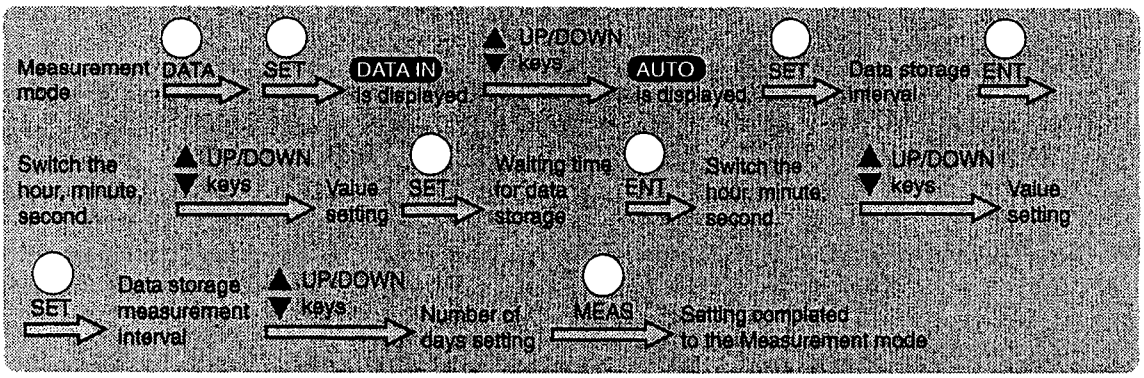
- Setting of data storage interval (4.2.1, step 4)
- Setting of waiting time for data storage (4.2.1, step 6)
- Setting of the data storage measurement period (4.2.1, step 8)



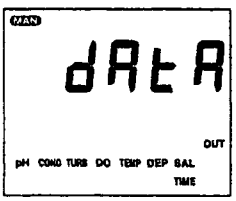
● indicates a storage point.

Indicates the start of the automatic data storage.
(Operation on page 39)

4.2.1 Data memory conditions settings



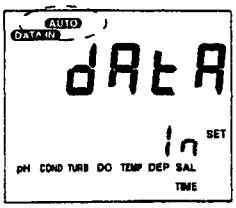
1. Press the **DATA** key in the Measurement mode.



2. Press the **SET** key.

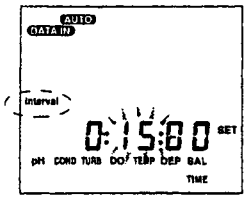
DATA IN is displayed.

3. Press the **UP/DOWN** (▲ ▼) keys to display AUTO.



4. Press the **SET** key to display the screen for setting the data storage interval Ⓐ.
"**Interval**" is displayed.

5. Press the **ENT** key to switch the among "hour", "minute" and "second" and set the value using the **UP/DOWN** (▲ ▼) keys.
(Data storage intervals can be set to 2 seconds to 24 hours.)
The current setting location will blink.

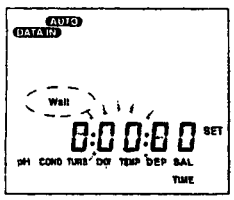


6. Press the **SET** key to display the screen for setting the waiting time for data storage Ⓑ.
"**Wait**" is displayed.

7. Press the **ENT** key to switch among "hour", "minute" and "second" and set the value using the **UP/DOWN** (▲ ▼) keys.
(The waiting time for data storage can be set to 2 seconds to 24 hours.)
The current setting location will blink.

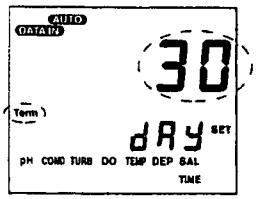
Important

- If wait time is set to "0", note that data is not stored in a memory the first time.



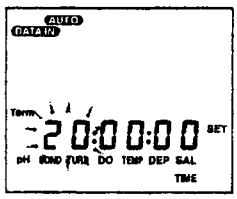
8. Press the **SET** key to display the screen for setting the data storage measurement period Ⓒ (number of days).
"**Term**" is displayed.

9. Use the **UP/DOWN** (▲ ▼) keys to set the value (number of days).



Setting of less than 24 hours

First set the number of days to 00 then press ENT key to select the "hour/minute/second" setting. Use the UP/DOWN (▲ ▼) keys to set the hour, the minute and second. During setting, the number to be set blinks.

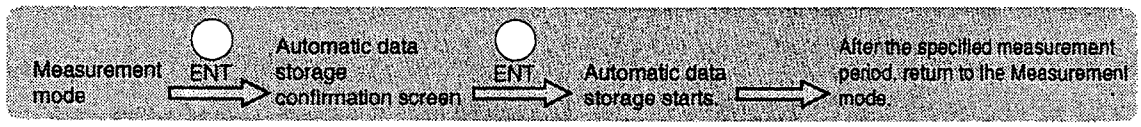


Note

- Press the SET key to return to step 4.

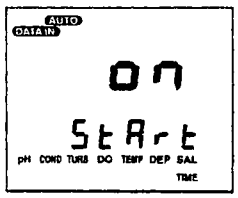
10. When the **MEAS** key is pressed, setting will be completed and the instrument will return to the Measurement mode.

4.2.2 Start of automatic data storage



1. Make sure that **AUTO** is displayed on the Measurement mode.

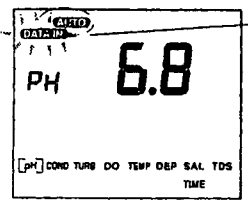
2. Press the **ENT** key. A confirmation screen will be displayed asking if you wish to start automatic data storage.



Note

- If you do not wish to proceed with automatic data storage, press the CAL key to return to the Masurement mode.

3. Press the **ENT** key to start automatic data storage.



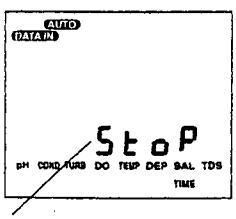
While **DATA IN** is blinking, the automatic data storage is being executed.

Note

- During the automatic data storage, measurement items can be switched by pressing the MEAS key.

Important

- During the automatic data storage, the ENT, SET, and DATA keys do not function and therefore calibration, setting change and stored data display cannot be performed.
- To stop automatic data storage, press the CAL key.



Confirmation display for canceling automatic data storage appears.
To stop the automatic data storage ..... Press the ENT key.
To return to the screen for the automatic data storage ... Press the DATA key.

4. After the specified measurement period, DATA IN disappears and the instrument returns to the normal Measurement mode.

Note

- When the instrument is turned on, AUTO lights up and DATA IN blink if automatic data storage is being performed with the sensor probe.

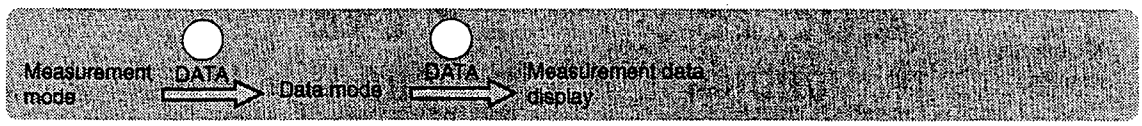
Notes for automatic data storage

- For long-term data storage, replace the sensor probe battery with a new one.
- You can remove the connector from the main unit. It can still be used for up to 60 hours at room temperature with the battery in the sensor probe (alkaline battery). Life is reduced by approximately one half when manganese batteries are used.
- If the sensor probe is connected to the instrument for monitoring, the instrument battery is first consumed to protect the memory of the sensor.
- When 2880 sets of data have been stored in the memory, ERR 9 appears and no more data can be stored. The automatic data storage is automatically ended and the instrument returns to the normal Measurement mode.
- Because ion sensors need to be calibrated once a day in measurements on the U-23 model, do not automatic data storage in the memory for more than a day.

4.3 Calling up data from the memory

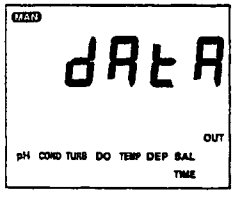
4.3.1 Calling up measurement data

Reading out data that has been stored manually or automatically.



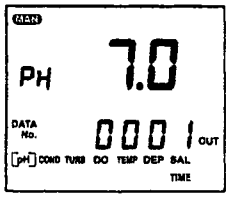
1. Press the **DATA** key in the Measurement mode.

The instrument goes to the DATA mode.



2. Press the **DATA** key.

The measurement data is displayed.
Data you want to call can be displayed by selecting a measurement item and data No.



DATA key ..... Selects switching of measurement item or memory data No.

When switching measurement items: Measurement item blinks.
When switching data No. : Data No. blinks.

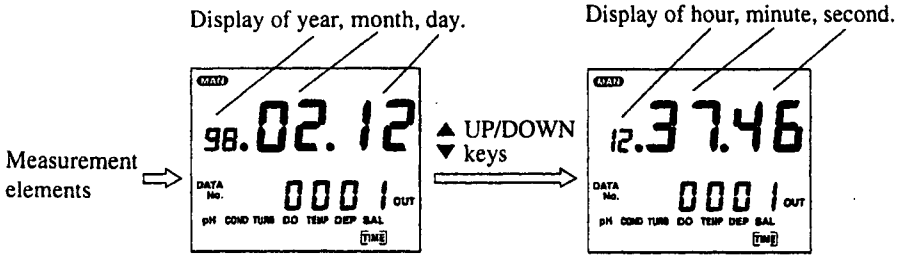
UP/DOWN (▲▼) keys .... Switch measurement item or No. which has been selected with the DATA key.

Note

- If you push the CAL key, only the data numbers will be displayed, allowing rapid changing of the numbers. Push the UP/DOWN (▲▼)keys to find the number, then press the SET key to display the data.

TIME data

Use the UP/DOWN (▲▼) keys to switch between "Yer, Month, Day" and "Hour, Minute, Second".

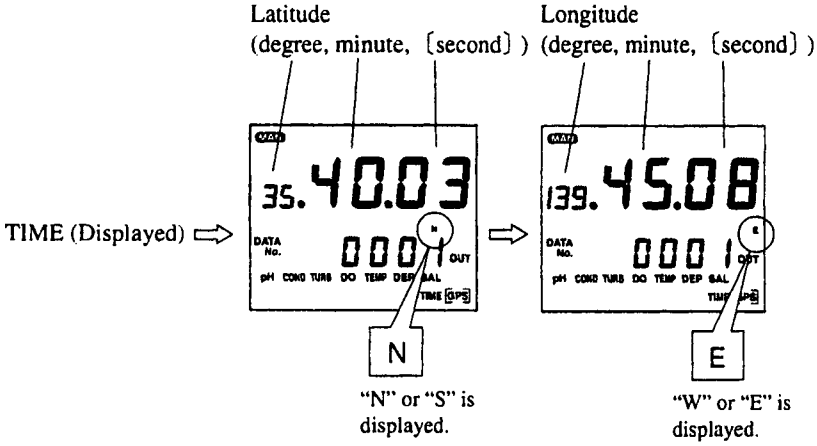


Note

- The time in the automatic memory can be out by about 2 seconds.

G.P.S. data (only when G.P.S. data is present)

Use the UP/DOWN (▲ ▼) keys to switch between "Latitude" and "Longitude".



Latitude N → The North latitude S → The South latitude
Longitude E → The East longitude W → The West longitude

ENT key ..... Prints all measurement data for the displayed memory data item.
(when the printer is connected to the instrument)

Useful uses of keys in automatic storage

SET + UP (▲) key ..... Displays the first part of the next data automatically stored.
SET + DOWN (▼) key ..... Displays the first part of the previous data automatically stored.
If there is manual data, then the previous or next manual data is shown.

Display for automatic storage

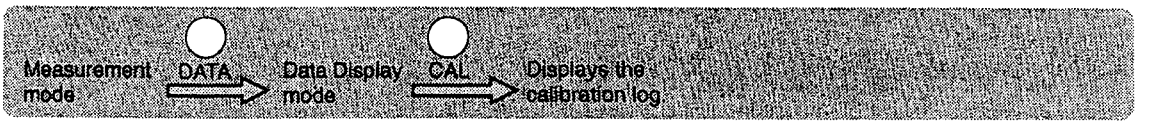
For the first and last data in one session of automatic storage the following identification marks are displayed in front of the values representing the data Nos.:
[: displayed for the first data in automatic storage.
] : displayed for the last data in automatic storage.

Note

- When the MEAS key is pressed, data calling is stopped and the instrument returns to the Measurement mode.
- Data is called from the sensor probe so to get one piece of data takes about one second.

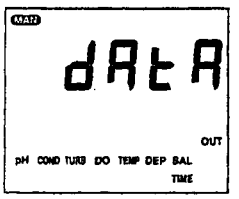
4.3.2 Calling up the calibration log

A calibration log is a record containing the "year, month, day" and "hour and minute" of the last calibration of individual measurement items and their calibration method. The instrument automatically stores the calibration log.



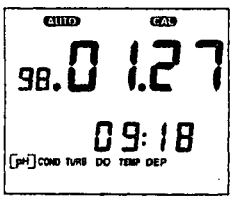
1. Press the **DATA** key in the Measurement mode.

The instrument goes to the DATA Display mode.



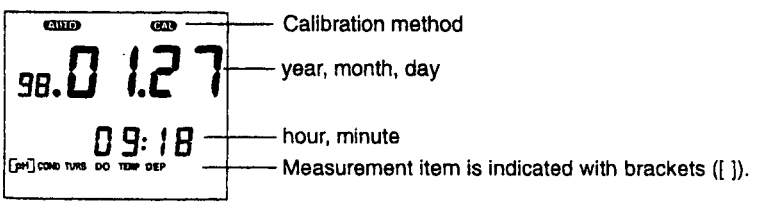
2. Press the **CAL** key.

The calibration log is displayed.



UP/DOWN (▲▼) keys: Switch the measurement item.
ENT key: Prints the entire calibration log. (when the printer is connected to the instrument)

Calibration log.



Calibration method

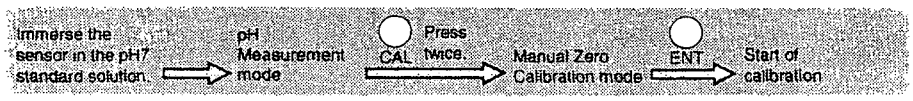
AUTO CAL	: AUTO calibration
MAN ZERO CAL	: Manual zero calibration
MAN SPAN CAL	: Manual span calibration
MAN ZERO SPAN CAL	: Manual zero calibration and span calibration

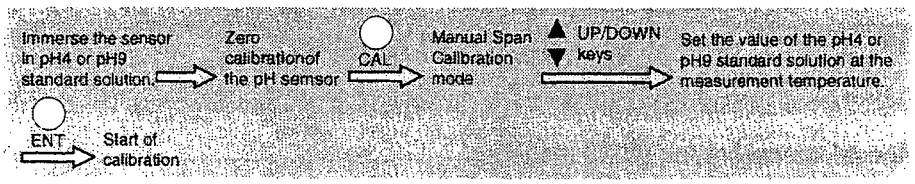
Note

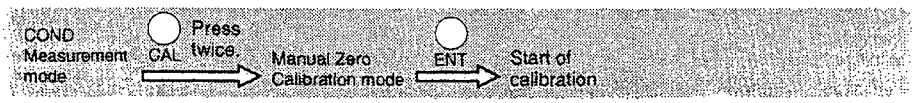
- Press the MEAS key to abort the data calling and return to the Measurement mode.

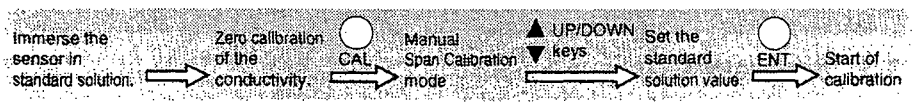
5. Techniques for more accurate measurement

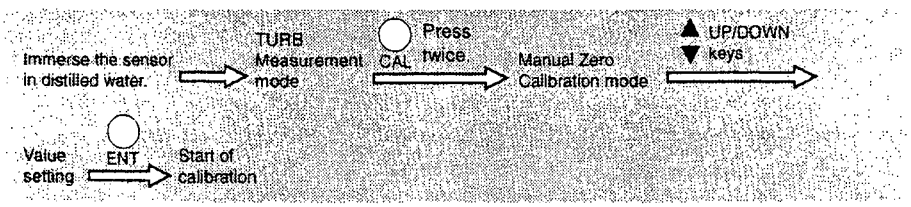
In normal operation, calibration using the AUTO Calibration mode described earlier in the basic operation section provides sufficient accuracy. However, for more accurate measurement, manual calibration is effective. When measurement with high-accuracy extended display is needed, be sure to perform manual calibration.
Attention: The extended display mode is entered automatically when manual calibration is selected.

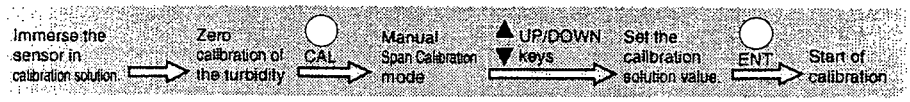


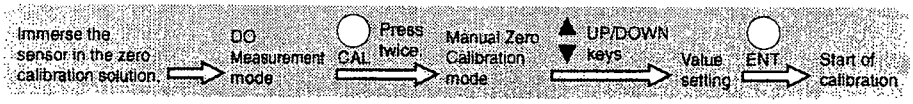


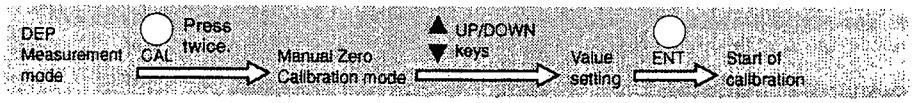


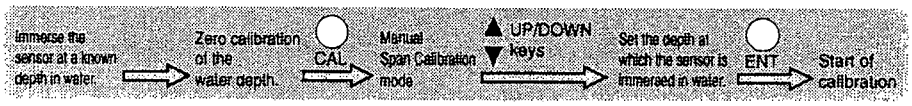


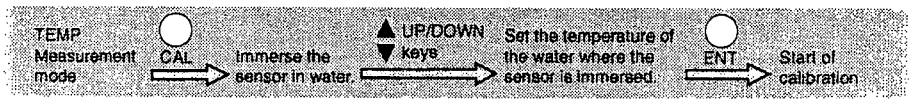


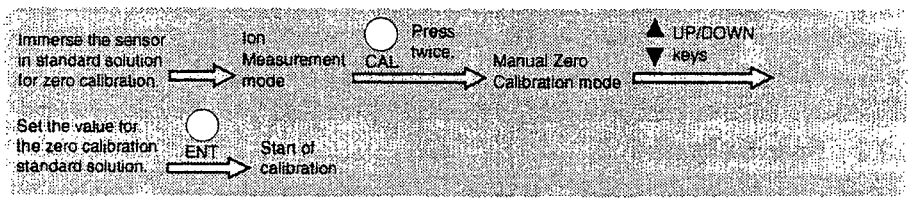


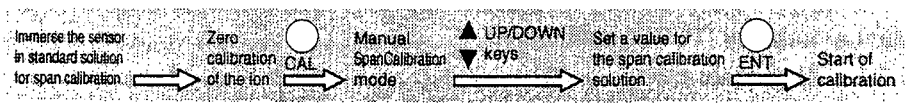






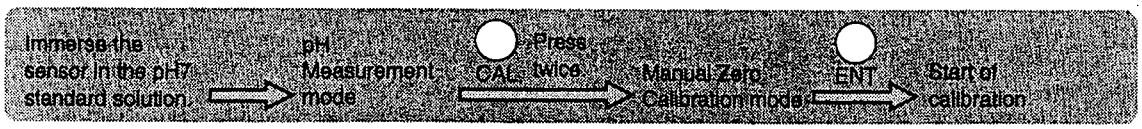






5.1 Manual pH calibration

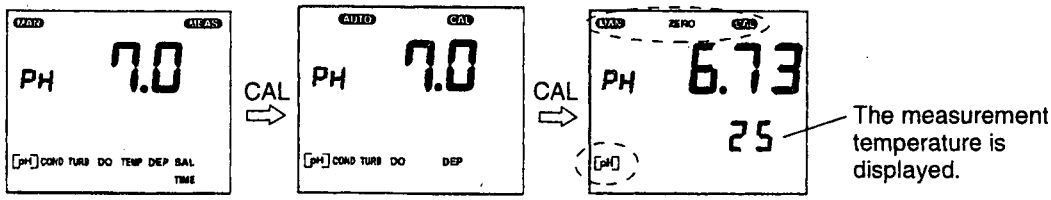
5.1.1 Zero calibration



1. Wash the sensor two or three times using distilled water, then pour some pH7 standard solution into the calibration beaker, and immerse the sensor in it. (For the U-23, immerse the sensor A side.)

2. Press the **CAL** key twice in the pH Measurement mode.

When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.

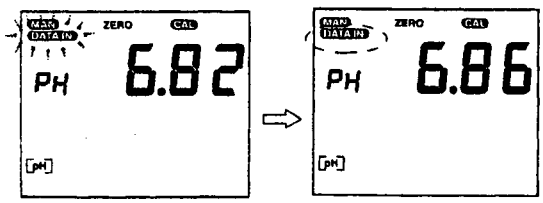


Manual Zero Calibration mode

3. Use the **UP/DOWN** (▲ ▼) keys to input the value for the pH7 standard solution at the measurement temperature.
(☞ *8. Reference data* page 98.)

4. Press the **ENT** key.

The manual zero calibration starts.

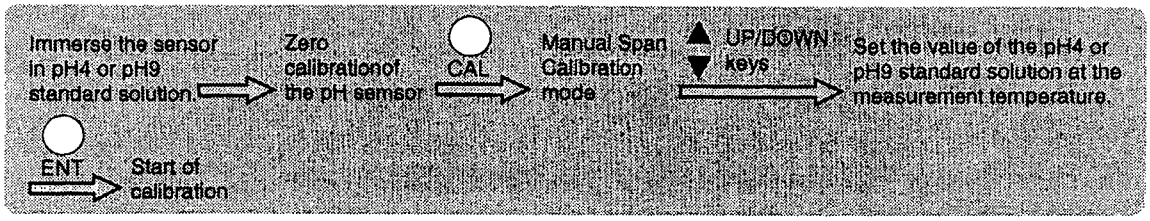


End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration ..... Press the ENT key.

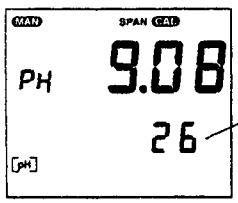
5.1.2 Span calibration



1. Wash the sensor two or three times using distilled water, then pour some pH4 or pH9 standard solution into the calibration beaker, and immerse the sensor in it. (For the U-23, immerse the sensor A side.)

2. After the zero calibration of the pH sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.
MAN, **SPAN** and **CAL** light up.

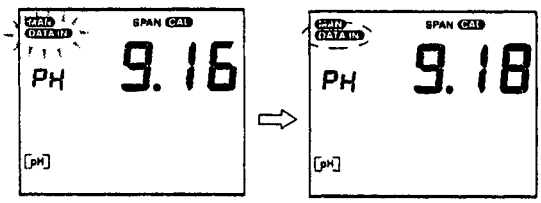
3. Use the **UP/DOWN** (▲ ▼) keys to set the value for the pH4 or pH9 standard solution at the measurement temperature.



The measurement temperature is displayed.

4. Press the **ENT** key.

The manual span calibration starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration ..... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

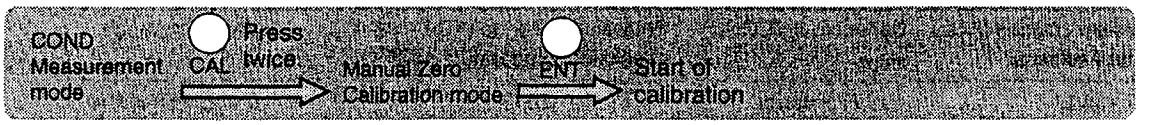
Note

- When the SET and CAL keys are pressed during the manual pH calibration mode, the calibration data for the pH sensor can be deleted.

5.2 Manual conductivity (COND) calibration

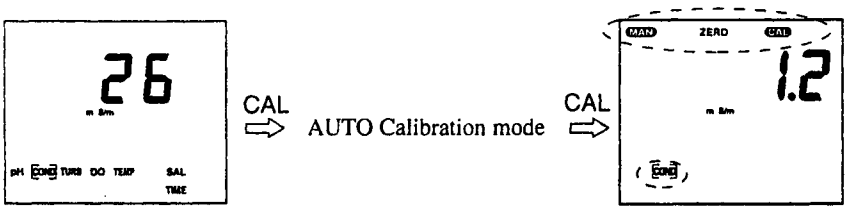
The U-20 series models can measure conductivity (COND) in the range from 0.90 to 9.99 S/m. Depending on the concentration of the sample, these models automatically select the most suitable measuring range from three ranges: 0.0 to 99.9 mS/m, 0.090 to 0.999 S/m, and 0.90 to 9.99 S/m. The zero point is common to the three measuring ranges.

5.2.1 Zero calibration



1. Wash the conductivity (COND) sensor two or three times using distilled water. Completely remove the water on the sensor and calibrate the instrument in the atmosphere.
2. Press the **CAL** key twice in the Conductivity (COND) Measurement mode.

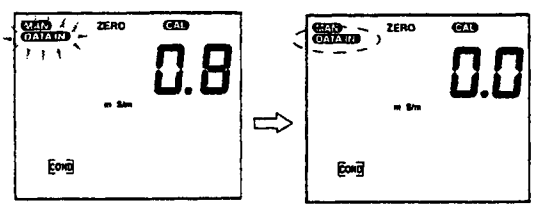
   When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.



Manual Zero Calibration mode

3. Use the **UP/DOWN** (▲ ▼) keys to set the value to 0.0.
4. Press the **ENT** key.

   The manual zero calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration ..... Press the ENT key.

5.2.2 Span calibration

Preparation of calibration solution (Potassium chloride (KCl) standard solution)

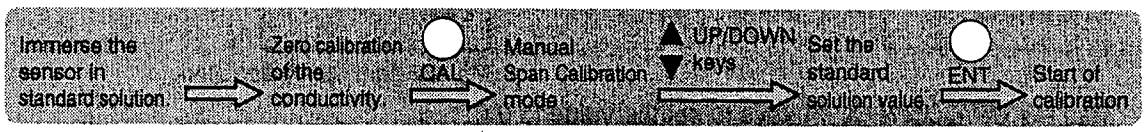
Dry Potassium chloride (KCl) powder (high-grade commercially available) at 105°C for two hours, and leave it to cool in a desiccator.
Consult the following table and measure a portion of potassium chloride (KC1), then prepare standard potassium chloride (KC1) solution following the procedure below.

Potassium chloride (KCL) standard solution	Conductivity (COND) value	Potassium chloride (KCl) weight (g) at solution temperature of 25°C	Calibration range
0.005 mol/L	71.8 mS/m	0.373	0.0 to 99.9 mS/m
0.050 mol/L	0.667 S/m	3.73	0.090 to 0.999 S/m
0.500 mol/L	5.87 S/m	37.2	0.90 to 9.99 S/m

1. Dissolve the weighed Potassium Chloride (KCl) in distilled water.
2. Put the dissolved Potassium Chloride (KCl) into a 1L measuring flask, and fill to the 1L mark with distilled water.

Calibration procedure

Perform the span calibration using the three types of standard solution as follows.

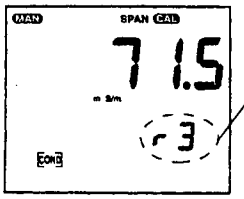


Important

- Set the temperature of the span standard solution to 25 ± 5°C.
- The sensor should be calibrated in the three standard solutions in the order of increasing concentration.

1. Wash the sensor two or three times using distilled water, then pour some standard solution into the calibration beaker, and immerse the sensor in it. (In the case of the U-23 model, immerse the sensor A side.)
2. After the zero calibration of the conductivity (COND) sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.
MAN. **SPAN** and **CAL** light up.

3. Use the **UP/DOWN** (▲ ▼) keys to set the standard solution value.



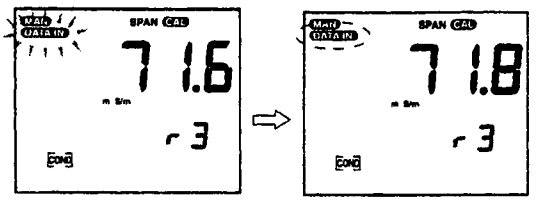
The calibration range is displayed.

Note

- The sensor automatically identifies the calibration solution and the relevant calibration range is displayed.
  - r 1 : 0.90 to 9.99 S/m
  - r 2 : 0.090 to 0.999 S/m
  - r 3 : 0.0 to 99.9 mS/m

4. Press the **ENT** key.

The manual span calibration is starts.



End of calibration

The measured value is displayed during calibration, and DATA IN blinks until the indicated value stabilizes. When the indicated value has stabilized, DATA IN lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration ..... Press the ENT key.

5. Press the **CAL** key and use each standard solution and perform steps 1 to 4 above for calibration.

6. Press the **MEAS** key to return to the Measurement mode.

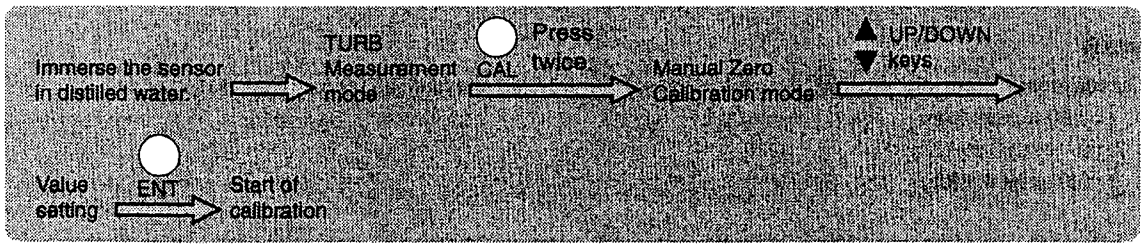
Note

- When the SET and CAL keys are pressed during the manual Conductivity (COND) Calibration mode. the calibration data for the conductivity (COND) sensor can be deleted.

5.3 Manual turbidity (TURB) calibration

5.3.1 Zero calibration

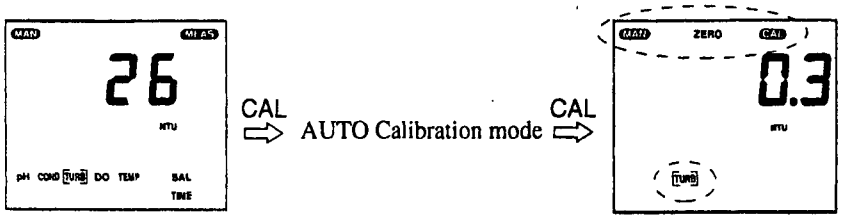
In zero calibration, distilled water is used as a calibration solution. If you cannot obtain distilled water, you may use ion exchange water, which can be considered to have a turbidity of zero.
When the turbidity (TURB) sensor is calibrated, it is particularly important that the probe is completely contamination-free. Do not use a contaminated probe. Otherwise unreliable calibration will result.



1. Wash the sensor two or three times using distilled water, then place some distilled water into the calibration beaker, and immerse the sensor in it. (For the U-23, immerse the sensor A side.)

2. Press the **CAL** key twice in the Turbidity (TURB) Measurement mode.

When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.

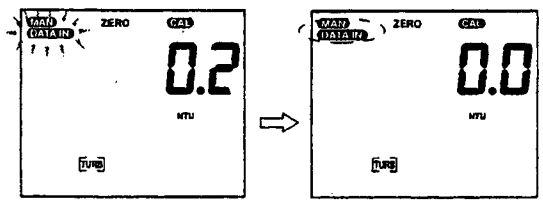


Manual Zero Calibration mode

3. Use the **UP/DOWN** (▲ ▼) keys to set the value to 0.0.

4. Press the **ENT** key.

The manual zero calibration is started.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

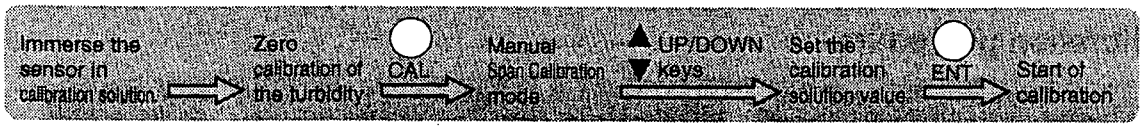
With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration ..... Press the ENT key.

5.3.2 Span calibration

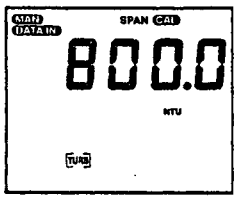
Preparation of calibration solution

Weigh out 5.0 g of hydrazine sulfate, and dissolve it in 400 mL of distilled water. Next dissolve 50 g of hexamethylene tetramine in 400 mL of distilled water, and mix the two solutions together. Finally add distilled water until the total solution volume is 1000 mL, and mix well. Store this solution at a temperature of 25 ± 3°C for 48 hours. The turbidity value (TURB) of this solution is equivalent to 4000NTU.
Use the solution as span calibration solution for turbidity (TURB) of 800NTU by diluting this solution by a factor of 5 (use a pipette to measure 50 mL of the 4000NTU solution and pour it into a 250 mL measuring flask, and add 200 mL of distilled water).

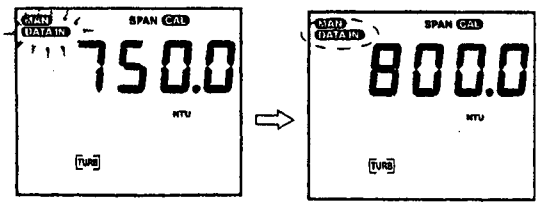
Calibration procedure



1. Wash the sensor two or three times using distilled water, then pour standard solution into a calibration beaker, and immerse the sensor in it. (For the U-23, immerse the sensor A side.)
2. After the zero calibration of the turbidity (TURB) sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.
   MAN, **SPAN** and **CAL** light up.
3. Use the **UP/DOWN** (▲ ▼) keys to set the value to 800.0.



4. Press the **ENT** key.
   The manual span calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration ..... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

Important

- When it is known beforehand that the solution for measurement has a low turbidity (0 to 100 NTU), calibrate the sensor in the span calibration solution of 80 NTU. To prepare an 80 NTU calibration solution, dilute the 4,000NTU calibration solution with distilled water by a factor of 50.

Note

- When the SET and CAL keys are pressed during the manual Turbidity (TURB) Calibration mode, the calibration data for the turbidity (TURB) sensor can be deleted.

5.4 Manual Dissolved-Oxygen (DO) calibration

It is necessary to prepare a new calibration solution each time directly before calibration of the Dissolved-Oxygen (DO) sensor.

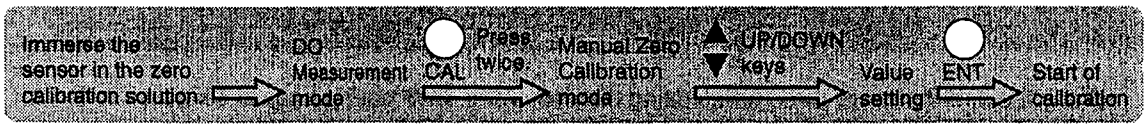
5.4.1 Zero calibration

Use ion exchange water or tap water with sodium sulfite dissolved in it.

Preparation of calibration solution

Add approximately 50 g of sodium sulfite to 1,000 ml of water (either ion exchange water or tap water) and stir the mixture to dissolve the sodium sulfite in it.

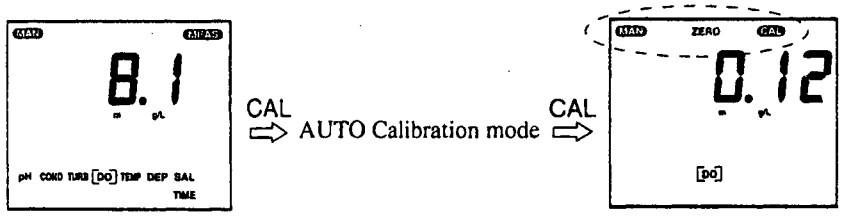
Calibration procedure



1. Use distilled water to wash the sensor a few times. Then fill the calibration beaker (above the marked line) with the zero calibration solution until the DO sensor can be immersed in the solution. Then immerse the sensor (the A side for the U-23 model) in the solution.

2. Press the **CAL** key twice in the Dissolved-Oxygen (DO) Measurement mode.

When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.

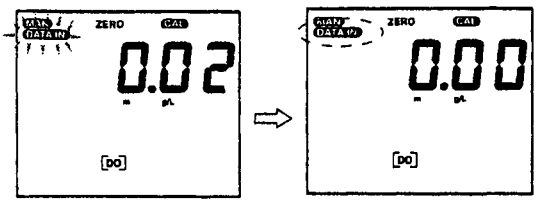


Manual Zero Caliburation mode

3. After the display has stabilized, use the **UP/DOWN** (▲ ▼) keys to set the value to 0.0.

4. Press the **ENT** key.

The manual zero calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking

To stop calibrating the sensor .... Press the CAL key.

To establish the calibration ..... Press the ENT key.

Important

- After calibration, use tap water to clean the sensor.

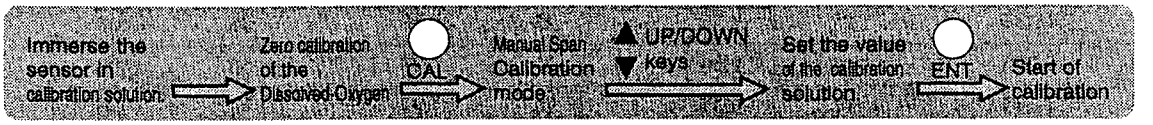
5.4.2 Span calibration

Use ion exchange water or tap water with saturated dissolved oxygen as the span calibration liquid.

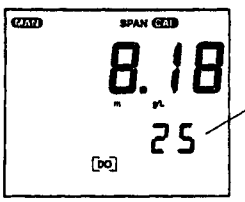
Preparation of standard solution for span calibration

Pour 1 to 2 liters of water into a container (either ion exchange water or tap water). Using a pneumatic pump, feed air into the water and froth up the solution until oxygen is saturated.

Calibration procedure



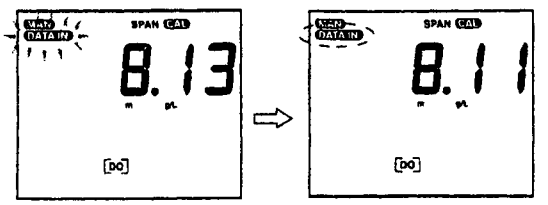
1. Wash the sensor twice or three times and immerse the sensor (the A side for the U-23 model) in the span calibration solution.
2. After the zero calibration of the Dissolved-Oxygen (DO) sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.
   MAN, **SPAN** and **CAL** light up.
3. After the display has stabilized, use the **UP/DOWN** (▲ ▼) keys to set the amount of saturated dissolved oxygen in water at the temperature.



The temperature setting is displayed.
Refer to the table given on page 56 and set a value equivalent to the amount of saturated dissolved oxygen at the temperature.

4. Press the **ENT** key.

The manual span calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration ..... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

Note

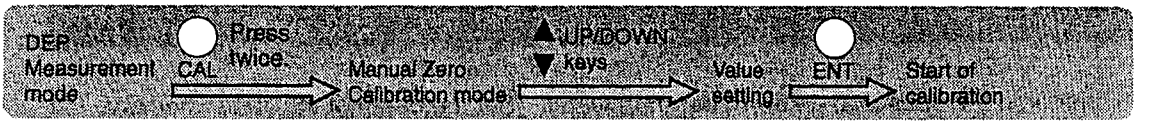
- When the SET and CAL keys are pressed during the manual Dissolved-Oxygen (DO) calibration mode, the calibration data for the dissolved-oxygen (DO) sensor can be deleted.

Amounts of saturated dissolved oxygen in water at various temperatures (salinity=0.0%)

Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	14.16						
1	13.77	11	10.67	21	8.68	31	7.42
2	13.40	12	10.43	22	8.53	32	7.32
3	13.04	13	10.20	23	8.39	33	7.22
4	12.70	14	9.97	24	8.25	34	7.13
5	12.37	15	9.76	25	8.11	35	7.04
6	12.06	16	9.56	26	7.99	36	6.94
7	11.75	17	9.37	27	7.87	37	6.86
8	11.47	18	9.18	28	7.75	38	6.76
9	11.19	19	9.01	29	7.64	39	6.68
10	10.92	20	8.84	30	7.53	40	6.59

5.5 Water depth (DEP) calibration

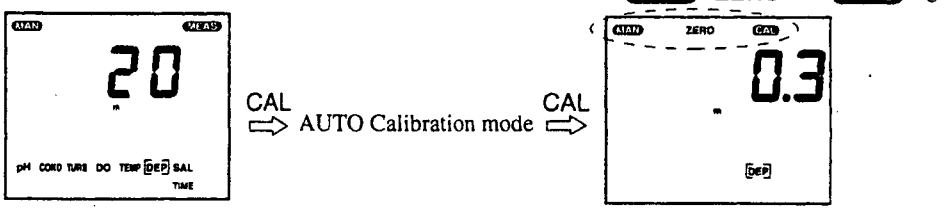
5.5.1 Zero calibration



1. Immerse the sensor in the sample water for approximately 30 minutes so that sensor probe and sample temperatures become the same.

2. Press the **CAL** key twice in the Water Depth (DEP) Measurement mode.

When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.



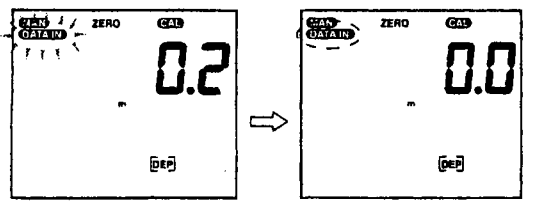
Manual Zero Calibration mode

Immerse the sensor probe so that the storage lid for a memory backup battery is at the water surface. The water surface level is considered as depth 0 m.

3. Use the **UP/DOWN** (▲ ▼) keys to set the value to 0.0.

4. Press the **ENT** key.

The manual zero calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking

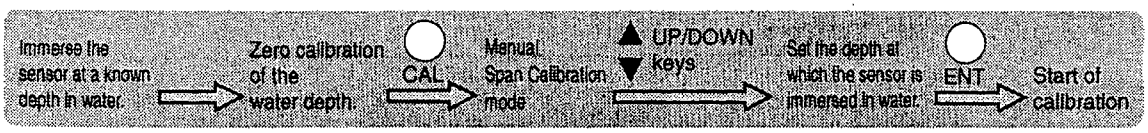
To stop calibrating the sensor .... Press the CAL key.

To establish the calibration ..... Press the ENT key.

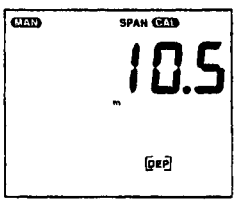
Important

- Since the water depth (DEP) sensor depends greatly on temperature, calibrate the sensor at the same temperature as the sample for more accurate measurement.
- Use the AUTO Calibration mode because calibration error becomes large when using in a place with flow velocity or where it is shallow.

5.5.2 Span calibration

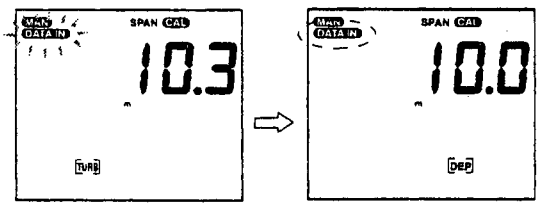


1. Immerse the sensor at a known depth in water. (Set the depth of the lid for memory backup battery as the depth setting.)
2. After the zero calibration of the water depth (DEP) sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.
   MAN, **SPAN** and **CAL** light up.
3. Use the **UP/DOWN** (▲ ▼) keys to set the depth at which the sensor is immersed in water.



4. Press the **ENT** key.

   The manual span calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

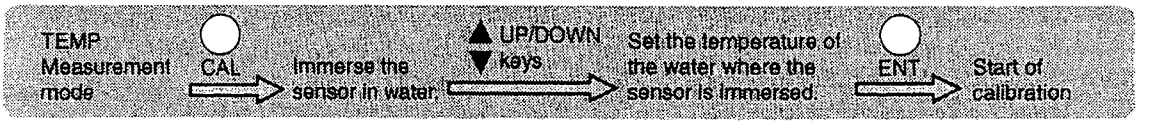
With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration ..... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

Note

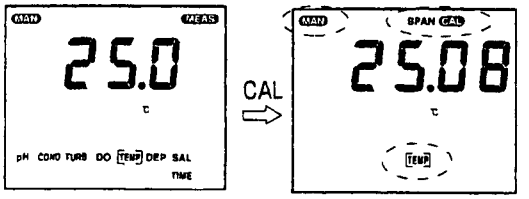
- When the SET and CAL keys are pressed during the manual Water depth (DEP) Calibration mode, the calibration data for the water depth (DEP) sensor can be deleted.

5.6 Temperature (TEMP) calibration



1. Press the **CAL** key in the Temperature (TEMP) Measurement mode.

Select the manual calibration mode.

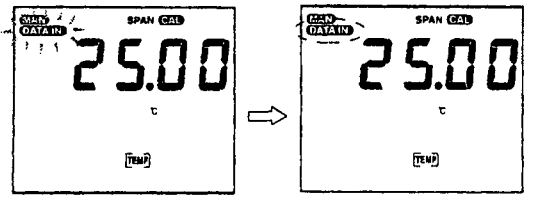


2. Immerse the sensor in water at a known temperature.

3. Use the **UP/DOWN** (▲ ▼) keys to set the temperature of the water where the sensor is immersed as a calibration value.

4. Press the **ENT** key.

The manual calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking

To stop calibrating the sensor .... Press the CAL key.

To establish the calibration ..... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

Note

- When the SET and CAL keys are pressed during the manual Temperature (TEMP) calibration mode, the calibration data for the temperature (TEMP) sensor can be deleted.

5.7 Manual ion calibration (U-23 model)

It is necessary to prepare a zero calibration solution and a span calibration solution according to the ion sensor to be calibrated. When the supplied standard ion sensors (Cl^-, NO_3^-, and Ca^{2+}) are used, the supplied ion standard solution can be used in common. When other sensors are used, it is necessary to set the ion valency first.
(☞ 6.7 *Changing the ion valency setting*)

5.7.1 Preparation of calibration solution

For standard ion sensors

To prepare a zero calibration solution, dilute the supplied ion standard solution (#130) by a factor of 10 with distilled water. The supplied ion standard solution (#130) is used without dilution as a span calibration solution. The supplied ion standard solution (#130) is used without dilution as a span calibration solution. The zero and span calibration values for the individual ion sensors are as follows:

Meter indication	ION	Zero calibration value	Span calibration value
ION1	Cl^-	3.55 mg/L	35.5 mg/L
	Chloride	(0.1m mol/L)	(1m mol/L)
ION2	NO_3^-	3.10 mg/L	31.0 mg/L
	Nitric acid	(50μ mol/L)	(0.5m mol/L)
ION3	Ca^{2+}	2.01 mg/L	20.1 mg/L
	Calcium	(50μ mol/L)	(0.5m mol/L)

For optional ion sensors

When calibrating any optional sensor, prepare a 0.1 mol/L standard solution first. Then dilute the standard solution to prepare a zero and a span calibration solution.

Preparing a 0.1 mol/L standard solution

Weigh out the individual reagents listed below for each ion type and dissolve each reagent in distilled water to obtain one liter of solution.

Ion type	Ion valency	Reagent (Special grade, commercial)	Weight	Concentration (mg/L)
Fluoride F^-	−1	Potassium fluoride	5.81 g	1900 mg/L
Potassium K^+	+1	Potassium chloride	7.46 g	3910 mg/L
Ammonia NH_3	+1	Ammonium chloride	5.35 g	1800 mg/L

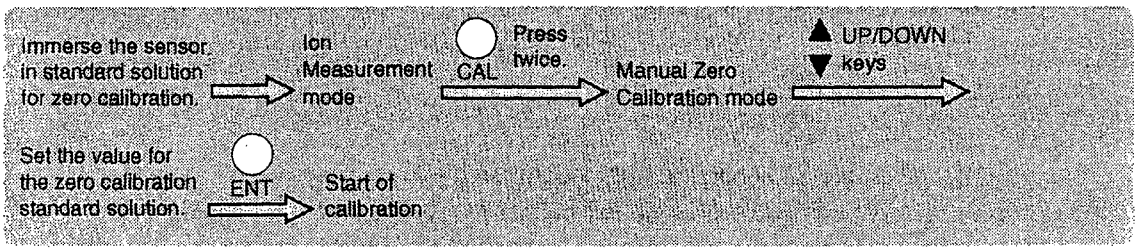
Preparing a calibration solution

To prepare a zero calibration solution and a span calibration solution , dilute the 0.1 mol/L standard solution for each ion type by a factor of 1000 and 100, respectively.

Ion type	Zero calibration solution	Span calibration solution
Fluoride F^-	1.9 mg/L (0.1m mol/L)	19 mg/L (1m mol/L)
Potassium K^+	3.9 mg/L (0.1m mol/L)	39 mg/L (1m mol/L)
Ammonia NH_3	1.8 mg/L (0.1m mol/L) + Sodium hydride*	18 mg/L (1m mol/L) + Sodium hydride*

* To prepare a standard solution for the ammonia ion sensor, place sodium hydride (0.4 g per 100 ml) into a standard solution for ammonium chloride directly before calibrating the ion sensor. A standard solution with sodium hydride changes with time because all of the ammonia content exists as ammonia gas. It is important to use the solution immediately.

5.7.2 Zero calibration



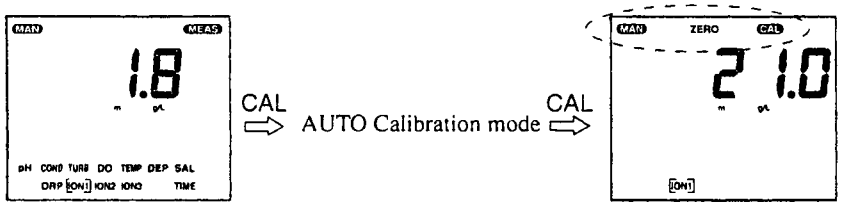
1. Wash the sensor with distilled water a few times. Then pour a zero calibration solution into the calibration beaker and immerse the sensor (the B side) into the solution.

Important

- Error messages are not displayed for ion sensor zero and span calibration. Immerse the sensor in the calibration solution and check the measured reading against the reference value before proceeding.

2. Select the measurement mode for each measurement item (ION1, 2, and 3) and press the **CAL** key twice.

When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.

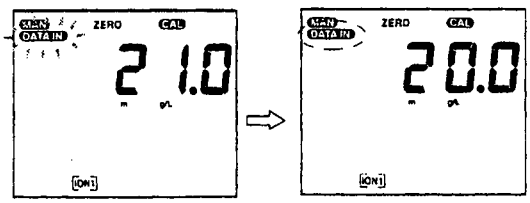


Manual Zero Calibration mode

3. Use the **UP/DOWN** (▲ ▼) keys to set the value for the zero calibration standard solution.

4. Press the **ENT** key.

The manual zero calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking

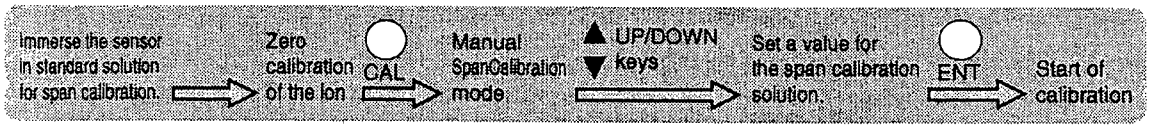
To stop calibrating the sensor .... Press the CAL key.

To establish the calibration ..... Press the ENT key.

Important

- For standard ion sensors, the common zero calibration solution is used. It is necessary to calibrate each of these ion sensors in the solution by performing the above procedure.
- For optional sensors, it is necessary to calibrate each of these ion sensors in the zero calibration solution for each ion sensor.

5.7.3 Span calibration



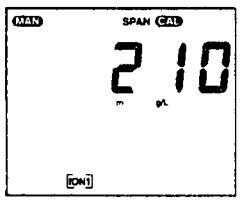
1. Pour the span calibration solution into the calibration beaker. Then wash the sensor with distilled water a few times and immerse the sensor (the B side) into the solution.

Important

- Error messages are not displayed for ion sensor zero and span calibration. Immerse the sensor in the calibration solution and check the measured reading against the reference value before proceeding.

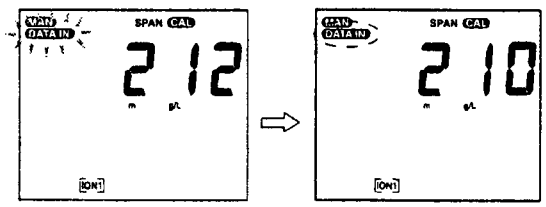
2. After the zero calibration of the ion sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.
MAN, **SPAN** and **CAL** light up.

3. Use the **UP/DOWN** (▲ ▼) keys to set a value for the span calibration solution according to the ion type.



4. Press the **ENT** key.

The manual span calibration is starts.



End of calibration

The measured value is displayed during calibration. and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized. **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration ..... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

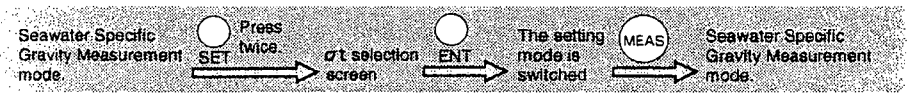
Important

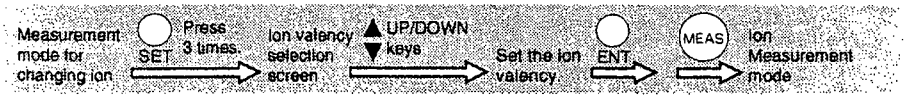
- For standard ion sensors, the common span calibration solution is used. It is necessary to calibrate each of these ion sensors in the solution by performing the above procedure.
- For optional sensors, it is necessary to calibrate each of these ion sensors in the span calibration solution for each ion sensor.

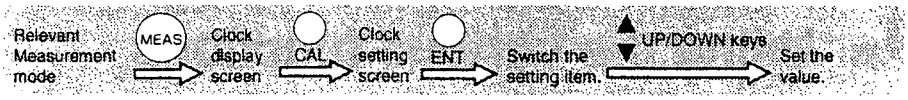
Note

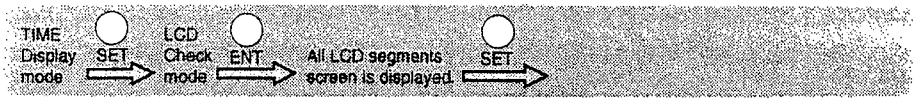
- When the SET and CAL keys are pressed during the relevant manual Ion calibration mode, the calibration data for the relevant ion sensor can be deleted.

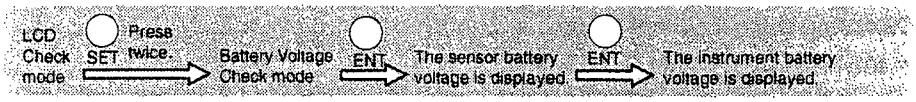
6. Using the various functions

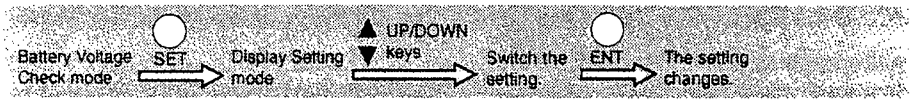


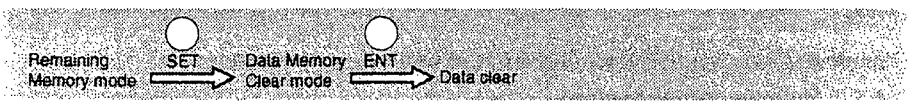


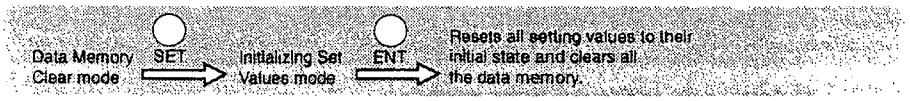


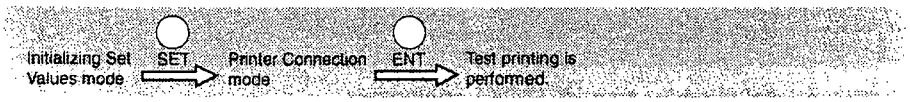






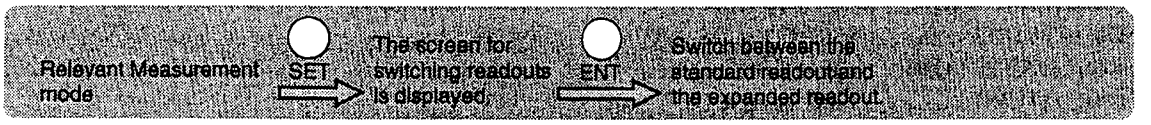






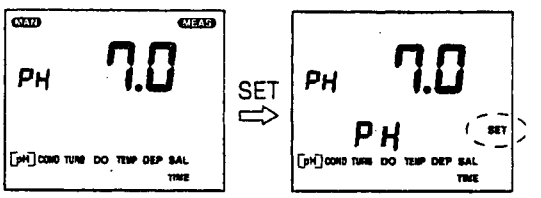
6.1 Switching to Expanded readout (High-accuracy display)

With the exception of oxidation-reduction potential (ORP), it is possible to switch between the Standard readout and the Expanded readout for the measurement value.



1. Press the **SET** key in the relevant Measurement mode.

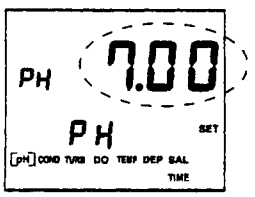
The screen for switching readouts is displayed.



Standard readout

2. Press the **ENT** key.

The screen can be switched between the standard readout and the expanded readout (High-accuracy display).



Expanded readout (High-accuracy display)

Note

- Switch readouts for each measurement items.
- Use the manual 2-point calibration (zero and span) when high accuracy is required for expanded readout (High-accuracy display).
- The expanded readout mode is automatically activated when the manual 2-point calibration mode is chosen.

3. Press the **MEAS** key to return to the Measurement mode.

6.2 Switching measurement units

It is possible to switch between measurement units.

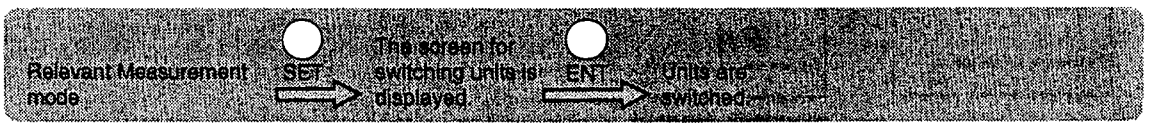
The units which can be switched are as follows:

pH ..... pH or mV
Conductivity (COND) ..... S/m or mS/cm
Water depth (DEP)..... m or ft
Ion concentration (ION) ..... g/L or mol/L
Turbidity (TURB) ..... NTU or mg/L
Dissolved Oxygen (DO) ..... mg/L or % (Oxygen saturation ratio)

Note

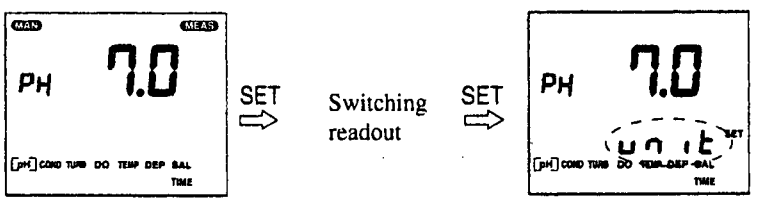
- When the measurement unit for ion is switched, the calibration value returns to the initial value.

In the case of pH, ION, TURB, DO



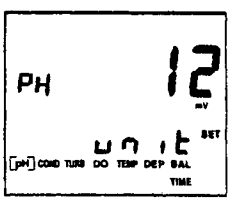
1. Press the **SET** key twice in the relevant Measurement mode.

Confirm that unit is displayed on the screen for switching units.



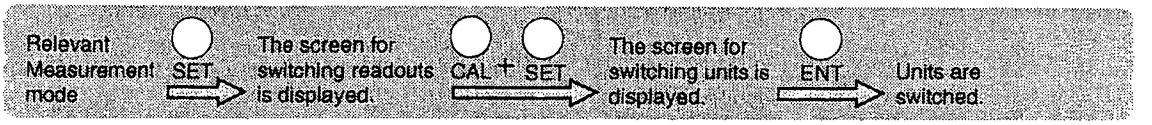
2. Press the **ENT** key.

Units are switched.



3. Press the **MEAS** key to return to the Measurement mode.

In the case of COND and DEP



1. Press the **SET** key in the Relevant Measurement mode.
   The screen for switching readout is displayed.
2. Press the **SET** key while holding down the **CAL** key.
   Confirm that unit is displayed on the screen for switching units.
3. Press the **ENT** key.
   Units are switched.
4. Press the **MEAS** key to return to the Measurement mode.

Measurement range

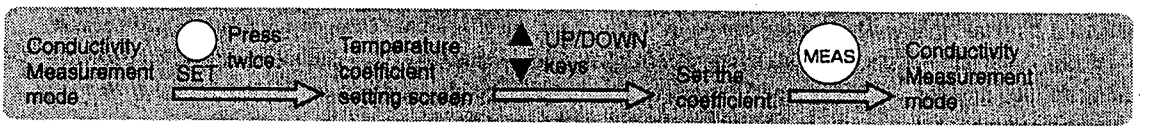
Measurement item		Measurement range		Measurement units
		Expanded	Standard	
pH		0.00 to 14.00	0.0 to 14.0	pH
		—	−1999 to 1999	mV in pH measurement
Conductivity (COND)	Range 1	0.90 to 9.99	0.9 to 9.9	S/m
		9.0 to 99.9	9 to 99	mS/cm
	Range 2	0.090 to 0.999	0.09 to 0.99	S/m
		0.90 to 9.99	0.9 to 9.9	mS/cm
	Range 3	0.0 to 99.9	0 to 99	mS/m
		0.000 to 0.999	0.00 to 0.99	mS/cm
Turbidity (TURB) *1		0.0 to 800.0	0 to 800	NTU (nephelometric turbidity units) or mg/L
Dissolved-oxygen (DO)		0.00 to 19.99	0.0 to 19.9	mg/L
		0.0 to 199.9	0 to 199	%
Temperature (TEMP)		0.00 to 55.00	0.0 to 55.0	°C
Water depth (DEP)		0.0 to 100.0	0 to 100	m
		0.0 to 330.0	0 to 330	ft
Salinity (SAL)		0.00 to 4.00	0.0 to 4.0	%
Total dissolved solids	Range 1	5.5 to 65.0	5 to 65	g/L
(TDS) *2	Range 2	0.55 to 6.50	0.5 to 6.5	g/L
	Range 3	0.000 to 0.650	0.00 to 0.65	g/L
Seawater specific gravity (σ_t)		0.0 to 50.0	0 to 50	–
Oxygen-reduction potential (ORP)		—	−1999 to 1999	mV
Ions 1, 2, and 3	Range 1	0.100 to 0.999	0.10 to 0.99	g/L, mg/L, μ g/L
		0.100 to 0.999	0.10 to 0.99	mol/L, mmol/L, μ mol/L
	Range 2	1.00 to 9.99	1.0 to 9.9	g/L, mg/L, μ g/L
		1.00 to 9.99	1.0 to 9.9	mol/L, mmol/L, μ mol/L
	Range 3	10.0 to 99.9	10 to 99	g/L, mg/L, μ g/L
		10.0 to 99.9	10 to 99	mol/L, mmol/L, μ mol/L

*1: Depending on the concentration range, the minimum turbidity is displayed as follows:
0 to 100 NTU ... 1 NTU for standard readout, 0.1 NTU for expanded readout.
100 to 800 NTU ... 10 NTU for standard readout, 1 NTU for expanded readout.

*2: The TDS range depends on the TDS factor settings. (Above ranges are given for a TDS coefficient of 0.65.)

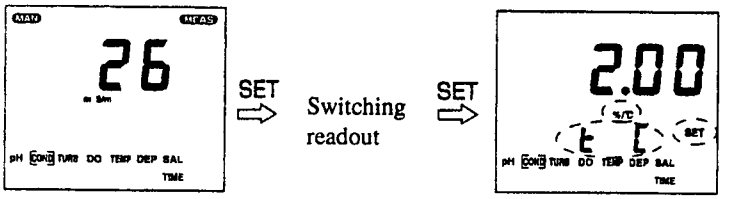
6.3 Temperature conversion for conductivity (COND)

Sample conductivity (COND) varies with temperature, and this instrument uses a temperature conversion coefficient to automatically standardize the conductivity (COND) to the value at 25°C. The initial setting value is 2%/°C, which is the generally used value.



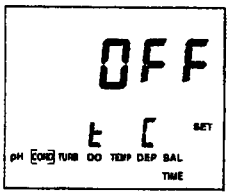
1. Press the **SET** key twice in the Conductivity (COND) Measurement mode.

The screen for setting temperature coefficients is displayed.



2. Use the **UP/DOWN** (▲ ▼) keys to set the coefficient.

The setting range is 0.00 to 3.00%/°C.



With the ENT key, the temperature conversion is switched between ON and OFF.

3. Press the **MEAS** key.

The instrument returns to the Conductivity (COND) Measurement mode.

Note

- For temperature coefficients, refer to *Reference data*, page 100 to 101.

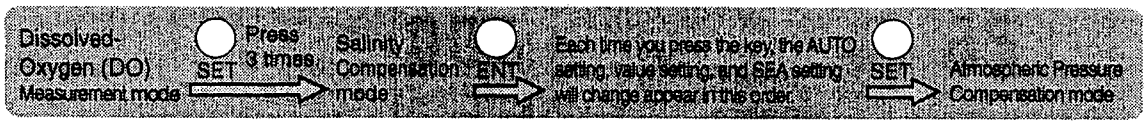
6.4 Dissolved-Oxygen (DO) environmental influence compensation

6.4.1 Salinity compensation

The indicated dissolved oxygen (DO) value can go over the actual value if salinity compensation isn't added because of the increase in salinity in the sample. To obtain a correct measured value for dissolved oxygen (DO) in the sample containing salinity, therefore, salinity compensation is needed. The following modes are available for calculation of salinity compensation.

AUTO..... Salinity compensation is performed automatically with salinity converted from a measured value for conductivity.

SEA ..... Compensation value appropriate for normal seawater is used.



1. Press the **SET** key 3 times in the Dissolved-Oxygen (DO) Measurement mode.

The salinity compensation mode currently set is displayed.

Important

- If you do not change the salinity compensation mode currently set, press the MEAS key to return to the Dissolved-Oxygen (DO) Measurement mode or press the SET key to select the Pressure Compensation mode.

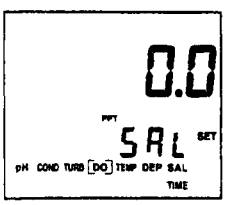
2. Press the **ENT** key.

The following screens are displayed in sequence each time the ENT key is pressed: AUTO setting, value setting, SEA setting and AUTO setting.

3. From the screen on which the value is displayed, use the **UP/DOWN** (▲ ▼) keys to enter the setting value if the salinity is known.

For AUTO and SEA setting, this step need not be performed.

The setting range is 0.0 to 40.0 PPT (parts per thousand).



4. When the **SET** key is pressed, setting will be completed and the instrument will enter the Pressure Compensation mode.

5. Press the **MEAS** key to return to the Dissolved-Oxygen (DO) Measurement mode.

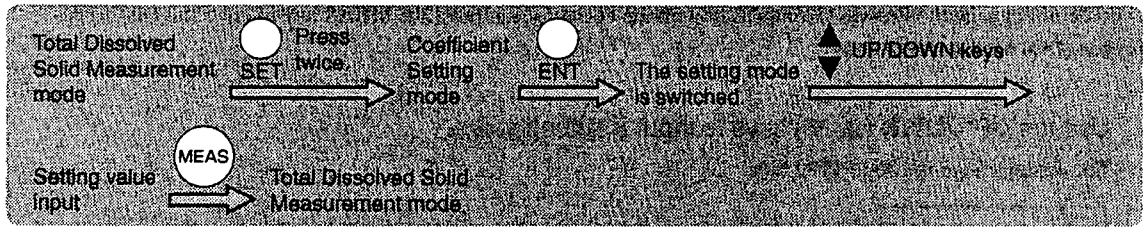
6.5 Setting a total dissolved solid (TDS) coefficient

The total dissolved solid amount (TDS) is a converted value obtained by multiplying the conductivity (COND) value by a known coefficient. Based on a conversion for KCl and $CaCO_3$ solutions, the coefficient initially set for the instrument depends on the conductivity (COND) value as shown below.

Conductivity (COND) (S/m)	Conversion coefficient
< 0.05	0.65
0.05 to 0.5	0.64
0.5 to 1	0.63
1 to 3	0.62
3 to 5	0.61
> 5	0.60

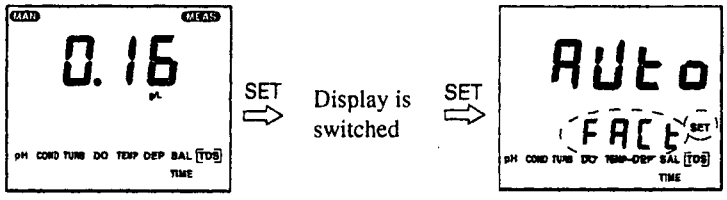
AUTO ..... Used to automatically calculate the total dissolved solid (TDS) amount with an initially set coefficient.

Setting value input ..... Used to determine the total dissolved solid (TDS) amount by setting any conversion coefficient irrespective of the conductivity (COND) value.



1. Press the **SET** key twice in the Total Dissolved Solid (TDS) Measurement mode.

The Coefficient Setting mode currently set is displayed.

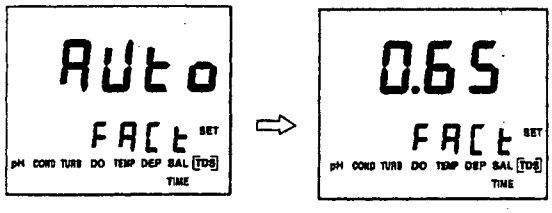


Important

- If you do not change the coefficient currently set, press the MEAS key to enter the Total Dissolved Solid (TDS) Measurement mode.

2. Press the **ENT** key.

The setting mode changes (AUTO/setting value input).



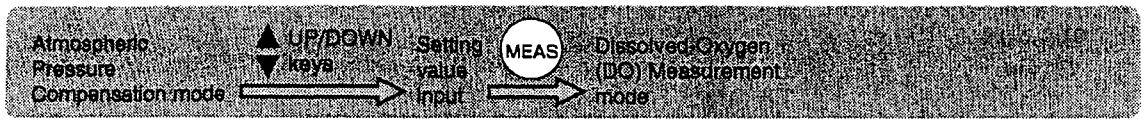
3. Use the **UP/DOWN** (▲ ▼) keys to input a setting value if required.

The setting range is 0.50 to 1.00.

4. When the **MEAS** key is pressed, setting will be completed and the instrument will enter the Total Dissolved Solid (TDS) Measurement mode.

6.4.2 Atmospheric pressure compensation

Differences in the atmospheric pressure of the measurement location influence the Dissolved-Oxygen (DO) measurement. By setting (input) the actual atmospheric pressure of the measurement location into the instrument, it is possible to standardize the measured Dissolved-Oxygen (DO) value to a value at the standard atmospheric pressure (1013 hPa).



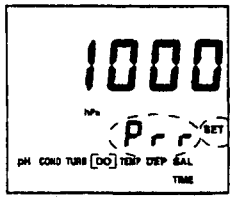
1. When the **SET** key is pressed on the salinity compensation screen, setting will be completed and the instrument will enter the Pressure Compensation mode.

Important

- If you do not change the Pressure Compensation mode currently set, press the MEAS key to enter the Dissolved-Oxygen (DO) Measurement mode.

2. Use the **UP/DOWN** (▲ ▼) keys to input a setting value.

The setting range is 100 to 1999 hPa.

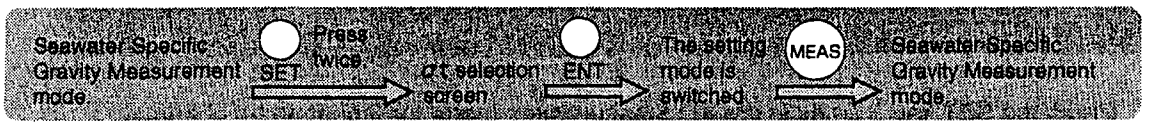


3. When the **MEAS** key is pressed, setting will be completed and the instrument will enter the Dissolved-Oxygen (DO) Measurement mode.

6.6 Displaying seawater specific gravity (σ_0, σ_{15})

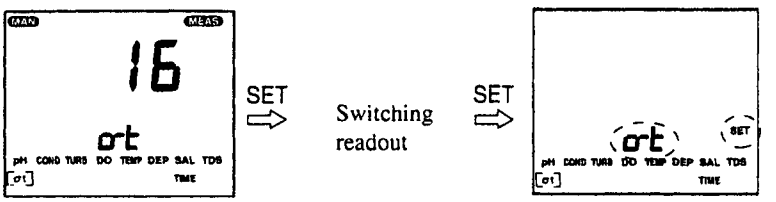
The specific gravity of seawater varies with temperature. By converting the measured value based on the value for a reference temperature, it is possible to compare sample measurement values at different temperatures.

- σ_t ..... Specific gravity of seawater at the measurement temperature.
- σ_0 ..... Seawater specific gravity at 0°C.
- σ_{15} ..... Seawater specific gravity at 15°C.



1. Press the **SET** key twice in the Seawater Specific Gravity (σ_t) Measurement mode.

Seawater specific gravity (σ_t) selection screen is displayed.



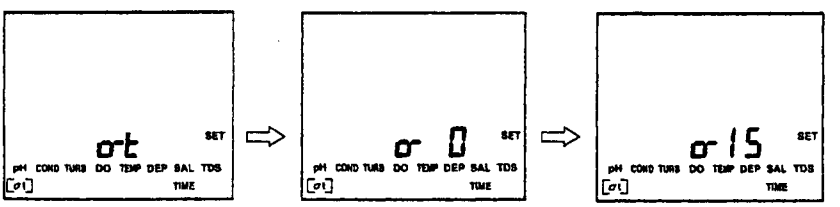
Important

- If you do not change the specific gravity currently set, press the MEAS key to enter the Seawater Specific gravity (σ_t) Measurement mode.

2. Press the **ENT** key.

The setting mode is switched.

($\sigma_0 \rightarrow \sigma_{15} \rightarrow \sigma_t \rightarrow \sigma_0 \ldots$)



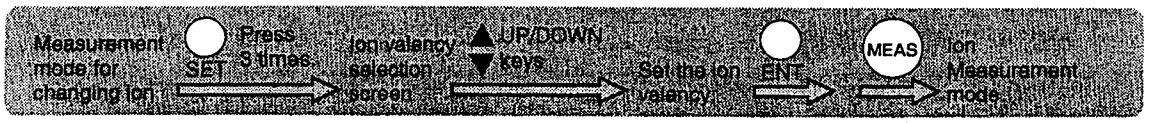
3. When the **MEAS** key is pressed, setting will be completed and the instrument will enter the Seawater Specific Gravity (σ_t) Measurement mode.

Note

- See page 102 for more about seawater specific gravity.

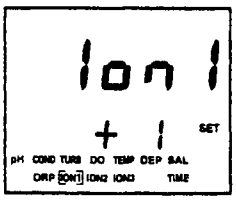
6.7 Changing the ion valency setting (U-23 model)

When you use the standard sensors (Cl^-, NO_3^- and Ca^{2+}), the ion valency has been already set in the initial settings, and no changes are required.
When other sensors than the standard ones are used, the ion valency must be set.



1. Press the **SET** key 3 times in the Ion Measurement mode for the ion to be changed.

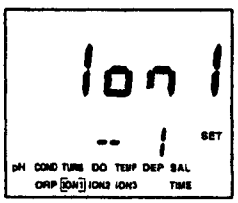
Ion valency selection screen is displayed.



Important

- If you do not change the ion valency currently set, press the MEAS key to enter the Ion Measurement mode.

2. Use the **UP/DOWN** (▲ ▼) keys to set the ion valency and press the **ENT** key.



UP (▲) : −2 → −1 → +1 → +2
DOWN (▼) : −2 ← −1 ← +1 ← +2

Important

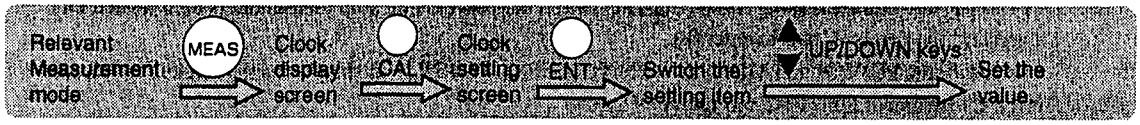
- The calibration data is cleared if the ion valency value is changed.

3. When the **MEAS** key is pressed, the setting will be completed and the instrument will enter the Ion Measurement mode.

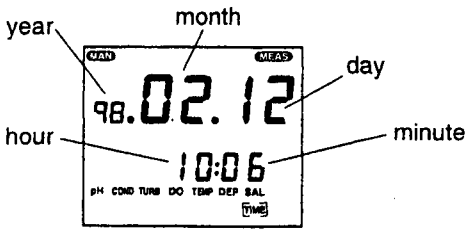
Note

- For the ion valency, refer to page 106.

6.8 Setting the clock

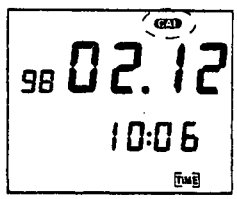


1. Use the **MEAS** key in the measurement mode to switch to the clock display screen.



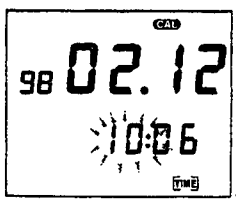
2. Press the **CAL** key.

CAL light up and clock setting screen is displayed.



3. Press the **ENT** key to switch the measuring item.

(year → month → day → hour → minute → year ...). The setting item will blink.



4. Use the **UP/DOWN** (▲ ▼) keys to set the value.

5. Press **SET** key to confirm the setting.

Note

- When the MEAS key is pressed, the instrument will return to the clock display.

Important

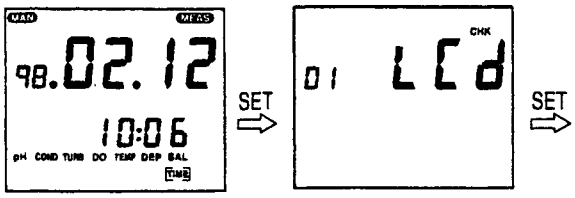
- When the MEAS key is pressed without pressing the SET key and the clock display is displayed again, settings are not changed.

6.9 Key lock setting

If you press the POWER key while pressing the UP (▲) key when the power is off, the instrument is then turned ON with the key locked and the key lock function works.
With the key locked, only the POWER and MEAS keys can be used and [LOCK] is displayed on the screen. To release this function, turn the instrument OFF first and then ON again.

6.10 Check mode

When the SET key is pressed in the measurement mode from the screen where "year, month, day and time" are displayed, the instrument performs self-diagnosis check.



Each time the SET key is pressed, the check mode item is switched sequentially.

Check mode items

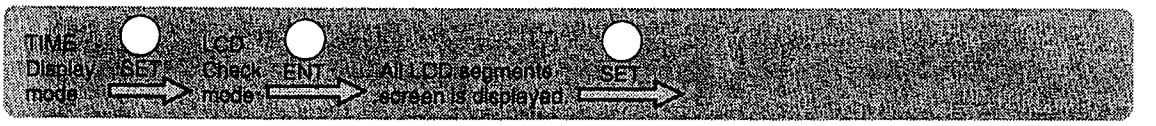
Item	Designation		Page
1	LCD check	Checks if all LCD segments will be displayed.	77
2	Battery voltage check	Performs a simple battery voltage check for the instrument and sensors.	78
3	Measurement item setting	Can set the measurement item to be stored.	79
4	Remaining memory	Displays the number of data that can be stored now.	80
5	Data memory clear	Clears the data memory.	81
6	Initializing set values	Initializes all memory settings.	82
7	Printer test	Performs a test print.	84

Note

- In the check mode, it is possible to return to the Measurement mode by pressing the MEAS key.

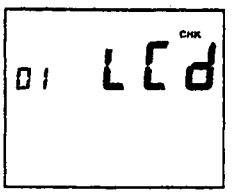
6.10.1 LCD check

All LCD segments are displayed.



1. Press the **SET** key in the Clock Display mode.

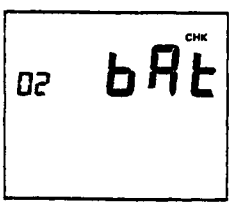
LCD check mode screen is displayed.



2. Press the **ENT** key.

3. Check to see if all LCD segments are displayed.

4. When the **SET** key is pressed, the instrument goes to the battery voltage check.

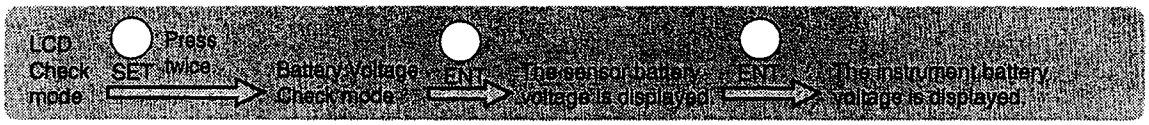


Note

- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

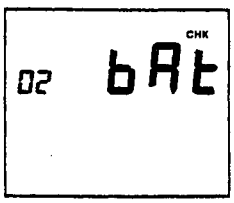
6.10.2 Battery voltage check

The battery voltage in use is displayed.



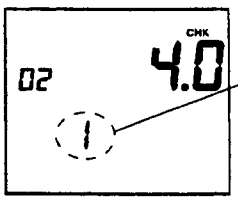
1. Press the **SET** key twice in the LCD Check mode.

Battery Voltage Check mode screen is displayed.



2. Press the **ENT** key.

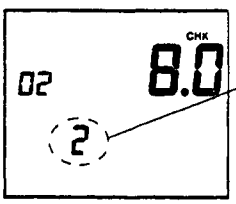
The sensor battery voltage is displayed.



1: Sensor battery voltage
Criteria
3 to 5.0 V : Normal
Less than 3 V: Replace the battery.
(Error No. 2 will blink.)

3. Press the **ENT** key.

The instrument battery voltage is displayed.



2: Instrument battery voltage
Criteria
5.5 to 11.0 V : Normal
Less than 5.5V: Replace the battery.
(Error No.3 will blink.)

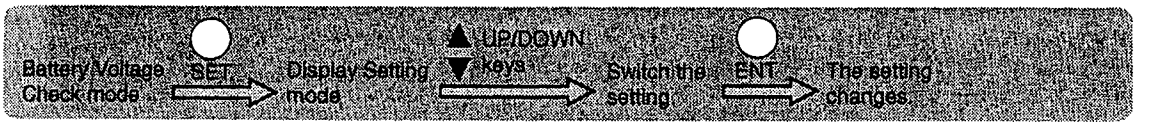
4. When the **SET** key is pressed, the instrument goes to the battery voltage check.

Note

- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

6.10.3 Measurement item setting

Measuring items can be set.

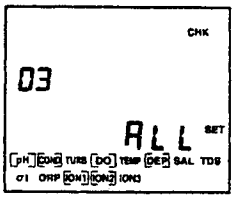


1. Press the **SET** key in the Battery Voltage Check mode.

Display setting mode screen is displayed.

2. Use the **UP/DOWN** (▲ ▼) keys to switch the measurement item.

The selected item blinks.



3. Press the **ENT** key to switch between [set/ not set] for the blinking item.

An item for which "set" is selected is indicated with [ ].

Note

- If the temperature is "not set" data for each component is not temperature-compensated and is displayed as data at 25°C.

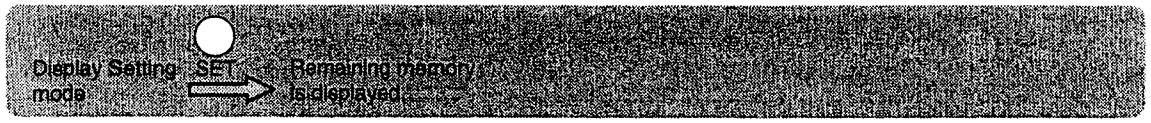
4. When the **SET** key is pressed, the instrument goes to the remaining memory display.

Note

- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

6.10.4 Remaining memory

The number of date that can be stored can be displayed.



Press the **SET** key in the Display Setting mode.

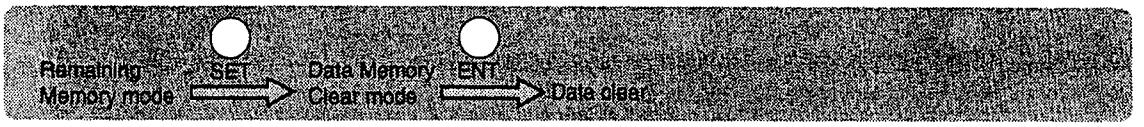
Remaining memory is displayed.

Note

- When the **SET** key is pressed, the instrument goes to the Data Memory Clear mode.
- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

6.10.5 Data memory clear

All the data memory is cleared.

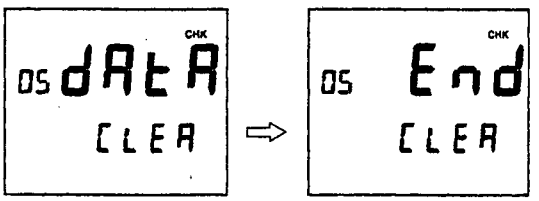


1. Press the **SET** key in the Remaining Memory mode.

   Data memory clear mode screen is displayed.

2. Press the **ENT** key.

   The data is cleared.



3. When the **SET** key is pressed, the instrument goes to the Memory Initialization mode.

Note

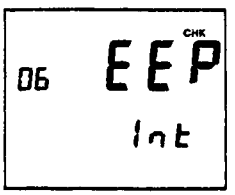
- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

6.10.6 Initializing set values

All setting values are reset to their initial state.

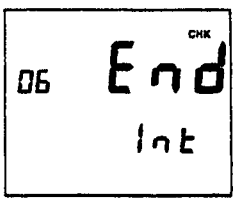
1. Press the **SET** key in the Data Memory Clear mode.

Initializing Set Values mode screen is displayed.



2. Press the **ENT** key.

All setting values are reset to their initial state.



3. When the **SET** key is pressed, the instrument goes to the Printer Connection mode.

Note

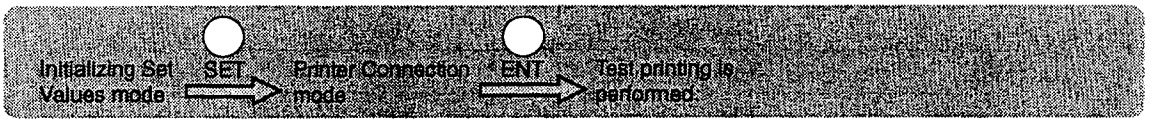
- When the MEAS key is pressed, the instrument return to the Clock Display mode.
- Data stored in the memory remains.

Initial setting

Item	Description	Initial value
Common	Display setting	Standard
	Data storage	Manual
pH	Unit	pH
COND	Unit	S/m
	Temperature coefficient	2.0 %/°C
DO	Salinity setting	AUTO
	Atmospheric pressure setting	1013 hPa
	Unit	mg/L
TURB	Unit	NTU
DEP	Unit	m
TDS	Coefficient	AUTO
σ_t	Unit	σ_t
ION	Unit	g/L
ION1	Ion type	-1
ION2	Ion type	-1
ION3	Ion type	+2

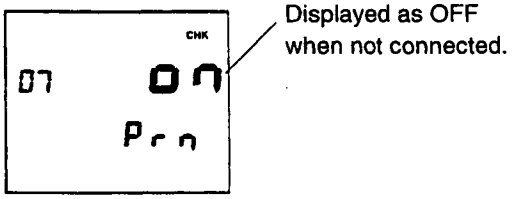
6.10.7 Printer connection, test print

This mode only operates when the function expansion unit is connected. A test print is performed if a printer is connected.



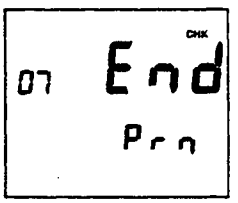
1. Press the **SET** key in the Initializing Set Values mode.

Printer Connection mode screen is displayed.



2. Press the **ENT** key to start printing.

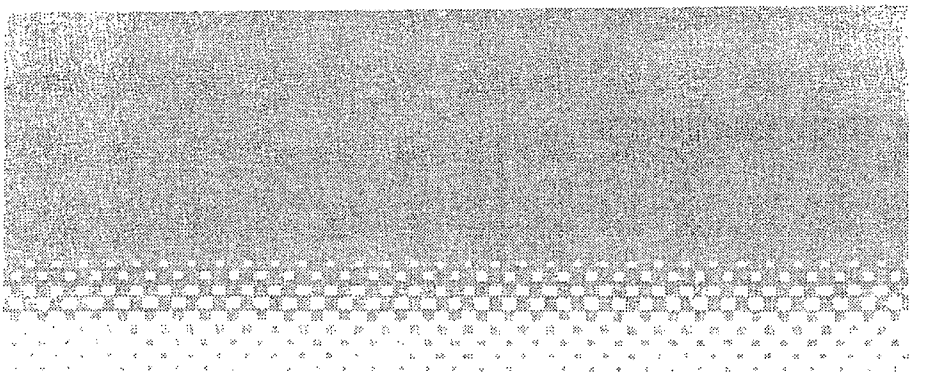
Normally, "End" is displayed. If an error has occurred, "Err" is displayed.



3. When the **SET** key is pressed, the instrument will return to the first LCD check mode.

Note

- When the MEAS key is pressed, the instrument returns to the Clock Display mode.



7. Instrument specifications

7.1 Daily maintenance

Sensor probe

● Storage

After use, clean the sensor probe in tap water and wipe off contamination. Next put distilled water into the calibration beaker to the marked line. Then attach the calibration beaker to the sensor probe and store the probe assembly in the carrying case.

Do not put water in the calibration beaker before attaching it to the ion sensor end (B side) of U-23.

For a long use

Wipe off contamination from the cable, sensor probe, and sensor before storage.

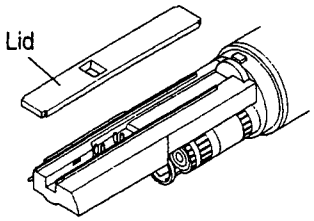
Important

- Do not put water in the calibration beaker before attaching it to the ion sensor end (B side) of U-23.

TEMP/COND/TURB units

● To remove contamination

1. Remove the lid from the cell.
2. Clean the unit in tap water. If the unit is severely contaminated, use an absorbent cotton to remove contamination.
3. Attach the lid to the cell block before storage.



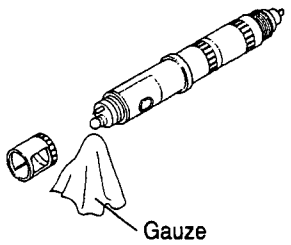
Important

- The cell has a window for turbidity measurement. Be careful to avoid damage to the window. In case of measurements, attach the lid to the cell in the correct direction.

pH/ORP sensors

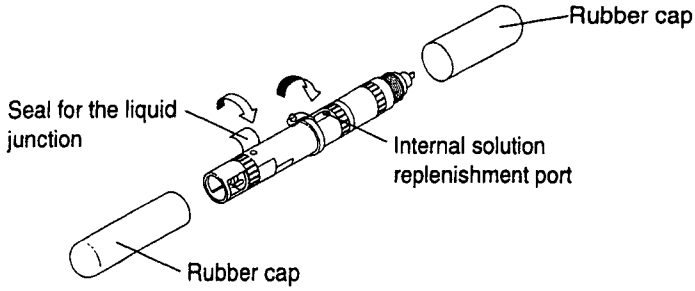
● To remove contamination

Use a piece of gauze dampened with detergent and wipe off contamination.



● Long-term storage

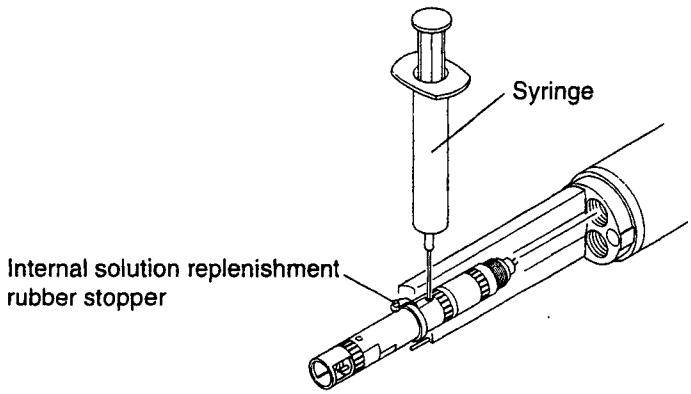
Remove the sensor from the sensor probe and check the internal solution replenishment port is closed. Then, attach a seal to the liquid junction and attach the rubber caps before storage.



● Monthly maintenance

Replace the internal solution as described below:

1. Remove the sensor from the sensor probe using a sensor spanner.
2. Open the internal solution replenishment rubber stopper and remove the internal solution with a syringe.
3. Pour new internal solution (#330) to the level near rubber stopper. Be careful to avoid air bubbles from coming in the solition.
4. Attach the sensor to the sensor probe.



DO sensor

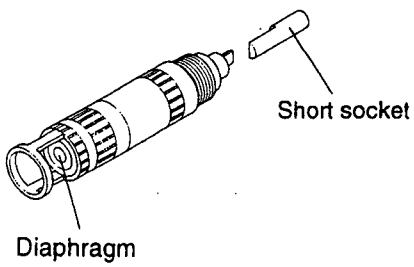
● To remove contamination

Wipe off contamination with gauze to avoid damage to the diaphragm.

● Long-term storage

Remove the sensor from the sensor probe using a sensor spanner. Set the supplied short socket and store the sensor in a cool, dark place.

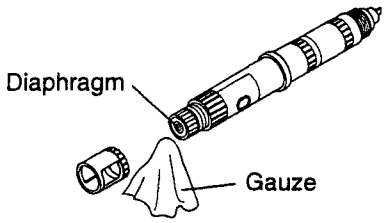
If the sensor probe is stored without a short socket, stable indications may not be obtained.



ION sensors (for the U-23 model only)

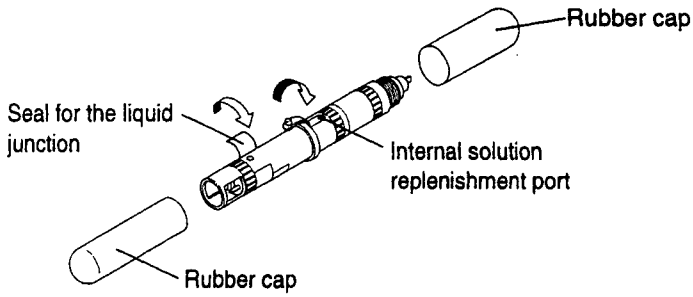
● To remove contamination

Use a piece of gauze dampened with water to wipe off contamination, being careful not to scratch it.



● Long-term storage

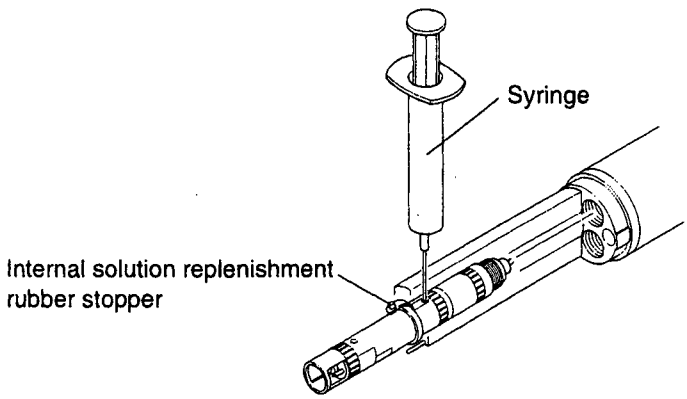
Use a sensor spanner to remove the sensor from the sensor probe and check the internal solution replenishment port is closed. Attach a seal for the liquid junction and attach the rubber caps to the sensor before storage.



● Maintenance at intervals of one week to one month

Replace the internal solution as described below:

1. Remove the sensor from the sensor probe using a sensor spanner.
2. Open the internal solution replenishment rubber stoper and remove the internal solution with a syringe.
3. Pour a new internal solution described in the sensor manual to the level near the rubber stopper. Be careful to avoid air bubbles from coming in the solution.
4. Attach the sensor to the sensor probe.



7.2 Troubleshooting

The instrument has a simple error message that informs users of operational errors and failure. Err No. is displayed at the bottom of the screen.

● Error message list

Err No.	Designation	Err No.	Designation
1	Sensor memory failure	6	Span calibration error
2	Sensor battery voltage drop	7	Calibration stability error
3	Instrument battery voltage drop	8	Printer error
4	Communications error	9	DATA IN error
5	Zero calibration error		

● Error and remedy

Important

- For err Nos. 5 to 7, the calibration err display disappears when a proper calibration is performed after the following action, or when the instrument is turned on again. For the other err Nos., the err display disappears after any of the following actions is taken.

Err NO.	Problem	Cause	Remedy
1	No data can be read from or written into the sensor probe memory.	Internal IC failure	Call your nearest store for sensor probe repair.
2	Sensor probe battery voltage drop	① Battery voltage drop ② Improper installation of the battery	① Replace the sensor probe battery. ② Set the batteries (LR03) in the correct direction.
3	Instrument battery voltage drop	① Battery voltage drop ② Improper installation of the battery	① Replace the instrument battery. ② Set the battery (6LR61) in the correct direction.
4	No communications possible between the instrument and the sensor probe	① Improper connection of the connector to the instrument ② Cable disconnection	① Connect the connector to the instrument properly and turn on the instrument again. ② Call your nearest store for cable repair.
5	No zero calibration possible	pH • The standard solution is contaminated. • Contamination on the pH glass membrane • Change in concentration of the internal solution for the reference electrode • Cracks in the pH glass electrode COND • The standard solution is contaminated. • The sensor is dirty. • The COND sensor is broken.	pH • Change the standard solution. • Clean the pH glass membrane. • Replace the internal solution for the reference electrode. • Replace the sensor. COND • Change the standard solution. • Clean the sensor. • Contact your nearest store.

Err NO.	Problem	Cause	Remedy
5	Zero calibration not possible	TURB • Air bubbles in the cell • Cell contamination DO • Damage to the diaphragm of the DO sensor DEP • Contamination on the DEP sensor • Damage to the DEP sensor	TURB • Swing the sensor probe while drawing a large arc. • Clean the cell. DO • Check the sensor and replace it if damaged. IDEP • Clean the DEP sensor. • Contact your nearest store.
6	Span calibration not possible	pH • Contamination on the pH glass membrane • Change in concentration of the internal solution for the reference electrode • Cracks in the pH glass electrode COND • The standard solution isn't correct. • The COND sensor is broken. TURB • Air bubbles in the cell • Cell contamination DO • Damage to DO sensor diaphragm DEP • Contamination on the DEP sensor • Damage to the DEP sensor TEMP • Damage to the TEMP sensor	pH • Clean the pH glass membrane. • Replace the internal solution for the reference electrode. • Replace the sensor. COND • Calibrate with correct standard solution. • Contact your nearest store. TURB • Swing the sensor probe while drawing a large arc. • Clean the cell. DO • Check the DO sensor and replace it if damaged. • Clean the DEP sensor. • Contact your nearest store. • Contact your nearest store.
7	The calibration value does not become stable within approximately three minutes.	① Sensor contamination ② Dry sensor surface ③ Severe temperature change	① Clean each sensor. ② Pour the standard solution into the calibration beaker. Calibrate the sensor again 1 to 2 hours later. ③ Calibrate the sensor in a place at a stable temperature or in a thermostatic oven.

Err NO.	Problem	Cause	Remedy
8	Printer unit failure		Turn OFF the instrument and use the remedy described below. Then turn ON the printer again.
		① Paper has jammed in the printer	① Remove the jammed sheet of paper
		② Improper printer unit connection	② Check to see if the printer is properl connected to the instrument.
		③ Printer failure	③ Replace the printer. * Contact your nearest store if the instrument does not recover after replacement of the printer.
9	Data cannot be stored because the memory is full.	No free space in the memory	Delete the data stored in the memory. (☞ Page 81)

● Other troubles

Remedies for various trouble with no Err No. displayed are described below.

Problem	Cause	Remedy
No data display with the power on	• No batteries	• Set new batteries.
	• Improper position of the positive and negative poles	• Set the batteries properly while paying attention to the positive and negative poles.
	• Battery voltage drop	• Replace the batteries with new ones.
	• Improper instrument battery contact	• Use radio pliers to narrow the positive terminal of the battery snap.
No setting change possible	• Automatic data storage is under way	• Press the CAL key to stop the automatic data storage.
No key operation possible	• The key lock function is working	• Turn OFF the instrument. Then turn ON the instrument again. (☞ Page 76)
	• Failure to calibrate the sensor or wrong calibration.	• Calibrate the sensor properly.
Blinking measured value	• Improper measurement sample	• Use a sample that is in the measurement range.
	• Sensor contamination	• Clean each sensor.
	• Poor calibration is possible. (The standard solution is contaminated.)	• Carry out correct calibration.
tYPE Err The Err is displayed and the operation cannot be performed.	• Improper connection of the cable connector to the instrument	• Connect the connector to the instrument properly and turn on the instrument again.
	• Cable disconnection	• Contact your nearest store.
	• Instrument inside failure	• Contact your nearest store.

7.3 Specifications of U-20 series models

NOTE ○: Applicable
—: Unapplicable

		U-22	U-23
Instrument	Water-proof construction	IP67	IP67
	Mass	Approximately 475g (including the grip holder)	Approximately 475g (including the grip holder)
Sensor *1	Use in 2-inch well	○	—
	Measurement temperature	0 to 55°C	0 to 55°C (except ion)
	Storage temperature	-5 to 60°C	-5 to 60°C
	Measurement depth *2	to 100m	to 100m (except ion)
	Maximum sensor outside diameter	46mm	95mm
	Sensor length	380mm	430mm
	Continuous use available *3	30 days	30 days (except ion)
	Automatic data gathering at set time	○	○
	Mass (Cable10m)	Approximately 1.5kg	Approximately 1.8kg
pH	Measuring principle	Glass electrode method	Glass electrode method
● Two-point calibration	Range	pH0 to 14	pH0 to 14
● Automatic temperature compensation	Resolution	0.01pH	0.01pH
	Repeatability	±0.05pH	±0.05pH
	Accuracy	±0.1pH	±0.1pH
Dissolved-Oxygen	Measuring principle	Diaphragm galvanic battery method	Diaphragm galvanic battery method
● Salinity conversion (0 to 40ppt/Auto)	Range	0 to 19.99mg/L	0 to 19.99mg/L
	Resolution	0.01mg/L	0.01mg/L
	Repeatability	±0.1mg/L	±0.1mg/L
● Automatic temperature compensation	Accuracy	±0.2mg/L	±0.2mg/L
Conductivity	Measuring principle	4 AC electrode method	4 AC electrode method
● Auto range	Range	0 to 9.99S/m	0 to 9.99S/m
● Automatic temperature conversion (25°C)	Resolution	0.1%F.S	0.1%F.S
	Repeatability	±1%	±1%
	Accuracy	±3%	±3%
Salinity	Measuring principle	Conductivity conversion	Conductivity conversion
	Range	0 to 4%	0 to 4%
	Resolution	0.01%	0.01%
	Repeatability	±0.1%	±0.1%
	Accuracy	±0.3%	±0.3%
Total Dissolved Solid (TDS)	Measuring principle	Conductivity conversion	Conductivity conversion
	Range	0 to 99.9 g/L	0 to 99.9 g/L
● Conversion factor setting	Resolution	0.1%F.S	0.1%F.S
	Repeatability	±2 g/L	±2 g/L
	Accuracy	±5 g/L	±5 g/L
Seawater specific gravity	Measuring principle	Conductivity conversion	Conductivity conversion
	Range	0 to 50 σ_t	0 to 50 σ_t
● Display σ_t, σ_0, σ_{15}	Resolution	0.1 σ_t	0.1 σ_t
	Repeatability	±2 σ_t	±2 σ_t
	Accuracy	±5 σ_t	±5 σ_t
Temperature	Measuring principle	Thermistor method	Thermistor method
	Range	0 to 55°C	0 to 55°C
	Resolution	0.01°C	0.01°C
	Repeatability	±0.3°C	±0.3°C
	Accuracy	±1.0°C	±1.0°C

		U-22	U-23
Turbidity (TURB)	Measuring principle	Penetration and scattering method	Penetration and scattering method
● Unit selection	Range (NTU or mg/L)	0 to 800NTU	0 to 800NTU
	Resolution	0.1NTU	0.1NTU
	Repetability	±3%	±3%
	Accuracy	±5%	±5%
Water depth	Measuring principle	Pressure method	Pressure method
	Range	0 to 100m	0 to 100m
	Resolution	0.1m	0.1m
	Repetability	±3%	±3%
	Accuracy	±5%	±5%
Oxidation-reduction	Measuring principle	Platinum electrode method	Platinum electrode method
potential (ORP)	Range	±1999mV	±1999mV
	Resolution	1mV	1mV
	Repetability	±5mV	±5mV
	Accuracy	±15mV	±15mV
Ion type	Measuring principle		Ion electrode method
● Auto range	Resolution	-	0.1%F.S
	Repetability	-	±5%
	Accuracy	-	±10%
	Range		
	Nitric acid ion	-	NO_3^-: 0.62 to 62000mg/L (pH3 to 7)
	Chloride ion	-	Cl^-: 0.4 to 35000mg/L (pH3 to 11)
	Calcium ion	-	Ca^{2+}: 0.4 to 40080mg/L (pH5 to 11)
	Fluoride ion	-	F^-: 0.02 to 19000mg/L (pH4 to 10: 20mg/L)
	Potassium ion	-	K^+: 0.04 to 39000mg/L (pH5 to 11: 3.9mg/L)
	Ammonia ion	-	NH_3: 0.1 to 1000mg/L (pH12 or more)
Simultaneous measurement items		10	13

Note: The accuracy rating value is obtained from measurements at intermediate point of the standard solution after two-point calibration (at room temperature and pressure). The repeatability and accuracy rating percentages are based on the full scale(except for salinity).

*1: Organic solvents, strong acids, and strong alkaline solvents cannot be measured.

*2: The maximum depth for ion measurements are 100 m for nitric acid ion, chloride ion, fluoride ion, 15 m for calcium ion, ammmonia, and 3 m for potassium ion.

*3: Based on the data measured automatically at 15 minutes intervals. The battery life taken into account. Periodical maintenance and calibration is necessary when a lot of shellfishes and seaweeds exist at the measurement point.

7.4 Spare parts

Spare parts list

Sensors

Sensor	Model	Spare part number	Compatible probe
pH sensor	6230	9037-0056-00	U-22/23
pH/ORP sensor	6280	9037-0057-00	U-22/23
DO sensor	5460	9037-0058-00	U-22/23
Nitric acid ion sensor *	6531	9037-0059-00	U-23
Chloride ion sensor *	6522	9037-0060-00	U-23
Calcium ion sensor *	6533	9037-0061-00	U-23
Ammonia gas sensor *	5012	9037-0062-00	U-23
Fluoride ion sensor *	6530	9037-0063-00	U-23
Potassium ion sensor *	6532	9037-0064-00	U-23

* A cartridge for ion sensor replacement and reference internal solution are also included in the ion sensors.

Cartridges for ion sensor replacement

Cartridge	Model	Spare part number
Nitric acid ion cartridge	7681	9003-0152-00
Chloride ion cartridge	7660	9003-0150-00
Calcium ion cartridge	7683	9003-0154-00
Potassium ion cartridge	7682	9003-0153-00
Fluoride ion cartridge	7661	9003-0151-00

Standard and internal solutions

Solution	Model	Spare part number
pH 4 standard solution (500 mL)	100-4	9003-0016-00
pH 7 standard solution (500 mL)	100-7	9003-0017-00
pH 9 standard solution (500 mL)	100-9	9003-0018-00
Powder for ORP standard solution (250 mL × 10)	160-51	9003-0031-00
Powder for ORP standard solution (250 mL × 10)	160-22	9003-0030-00
pH reference internal solution (250 mL)	330	9037-0052-00
Ion one-point standard solution (250 mL)	130	9037-0065-00
Nitric acid ion sensor reference internal solution (50 mL)	302	9037-0066-00
Chloride ion sensor reference internal solution (50 mL)	301	9037-0067-00
Calcium and fluoride ion sensor reference internal solution (250 mL)	300	9003-0032-00
Potassium ion sensor reference internal solution (50mL)	303	9037-0069-00
Ammonia gas sensor reference internal solution (50mL)	370	9012-0009-00

Others

	Model	Spare part number
Diaphragm for ammonia gas sensor (6 pcs.)	–	9037-0070-00
Calibration beaker	–	9037-0073-00
Connector plug for the prove	–	9037-0071-00
Sensor spanner	–	9037-0072-00
DO diaphragm replacement kit		9037-0074-00
Battery cover packing		9096-0013-00
System unit cover O-ring		9096-0014-00

* The spare parts above are prepared by dealers.
Order the part by designating the parts name, model and spare parts number.

7.5 Option

Parts name	Model
Expansion adaptor	U-2001
System unit *	U-2002-100V
	U-2002-110V
	U-2002-220V
AC adaptor (for 100V)	AC-10

* Specify the power source and voltage of the printer when ordering.

8. Reference Data

● pH measurement

1. Principle of pH measurement

U-20 series use the glass electrode method for pH measurements. The glass electrode method measures a potential difference between the glass film for pH and the comparison electrode. For more information, refer to JIS Z 8802 pH measurement method.

2. Temperature compensation

The electromotive force generated by the glass electrode changes depending on the temperature of the solution. Temperature compensation is used to compensate for the change in electromotive force caused by temperature.
This function does not compensate the change in pH caused by the temperature of the solution. When pH is to be measured, the temperature of the solution when the pH is measured must be recorded along with that pH value, even if a meter that has automatic temperature compensation is used. If the solution temperature is not recorded, the results of the pH measurement may be meaningless.

3. Types of standard solutions

When measuring pH, the pH meter must be calibrated using a standard solution. There are five kinds of standard solutions specified in "JIS 28802 pH measurement". For normal measurement, two of standard solutions with a pH of 4, 7, and 9 are sufficient to accurately calibrate the meter.
For standard solutions, refer to "JIS Z 8802 pH measurement".

pH 4 standard solution ..... 0.05 mol/L potassium hydrogen phthalate aqueous solution (Phthalate)
pH 7 standard solution ..... 0.025 mol/L potassium dihydrogenphosphate, 0.025 mol/L sodium phospate aqueous solution (Neutral phosphate)
pH 9 standard solution ..... 0.01 mol/L tetra-sodium boric acid aqueous solution (Borate)

pH values of pH standard solutions at various temperatures settings.

Temp. (°C)	pH 4 standard solution Phthalate	pH 7 standard solution Neutral phosphate	pH 9 standard solution Borate
0	4.01	6.98	9.46
5	4.01	6.95	9.39
10	4.00	6.92	9.33
15	4.00	6.90	9.27
20	4.00	6.88	9.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14
35	4.02	6.84	9.10
40	4.03	6.84	9.07
45	4.04	6.84	9.04

4. Supplements for pH measurement

Pressure compensation diaphragm

U-20 series can measure pH with high accuracy through the pressure compensation diaphragm without being affected by hydraulic pressure. Attention should be paid to the following points so that the diaphragm may function fully.
Before measurement, use a syringe and fill the reference electrode up to the replenish port with the internal solution.
When injecting the polarity reference internal solution, be careful that air bubbles do not get into the solution.

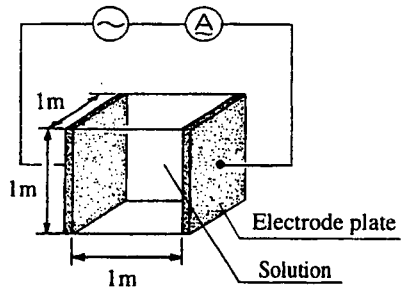
● COND measurement

1. Four-AC-electrode method

Conductivity is an index of the flow of electrical current in a substance.

Salts dissolved in water are separated into cations and anions. Such solution is called electrolytic solution. Electrolytic solution has the property of allowing the flow of current according to Ohm's law. This property is referred to as ionic conductivity, since current flow is caused by ion movement in electrolytic solution. Metals, on the other hand, allow the flow of current by means of electrons. This property is called electronic conductivity, which is distinguished from ionic conductivity.

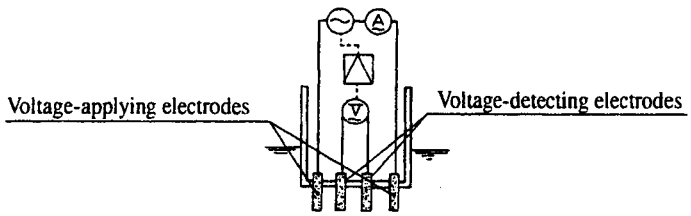
A cube with 1 cm on each side, as shown in Fig. 1, is used to demonstrate an electrolytic solution. Two electrode plates are placed on opposite sides, and the cube is filled with a solution. If the resistance between these two electrode plates is represented by r (Ω), the conductivity of the solution L ($S.m^{-1}$) is represented as L=1/r. S stands for Siemens, a unit of measurement of conductance.



(Fig. 1 Definition of conductivity)

The most general method for measuring conductivity is based on the above principle, and is called the 2-electrode method. In the 2-electrode method the influence of polarization cannot be ignored for solutions with high conductivity and conductivity cannot be measure accurately. In addition, contamination on the surface of the electrode increases apparent resistance, resulting in inaccurate measurement of conductivity.

The U-20 series has adopted the 4-electrode method to overcome these disadvantages of the the 2-electrode method. As shown in Fig. 2, the U-20 series uses two voltage-detecting electrodes and two voltage-applying electrodes, for a total of four electrodes. The voltage-detecting electrodes are for detecting AC voltage, and the voltage-applying electrodes are for applying AC voltage.



(Fig. 2 Principle of the 4-electrode method)

Let us assume that the current, I (A), flows in a sample of conductivity L – under automatic control of the voltage-applying electrodes – so that the voltage at the voltage detecting-electrodes, E (V), remains constant at all times. Then, the resistance of the sample, R (Ω), across the voltage-detecting electrodes is represented as R=E/I. The resistance, R, of the sample is inversely proportional to its conductivity, L. Accordingly, a measurement of conductivity, Is, of a standard solution of known conductivity, Ls, enables calculation of conductivity of a sample according to the formula L = Ls (I/Is) from the ratio L : Ls = I : Is.

Even in the 4-electrode method, polarization occurs, since AC current flows in the voltage-applying electrodes. The voltage-detecting electrodes are, however, free from the effects of polarization, since they are separated from the voltage-applying electrodes, and furthermore, current flow is negligible. Therefore, the 4-electrode method is an excellent method to enable measurement of conductivity covering a very high range.

2. SI units

New measurement units, called SI units, have been in use from 1996. Accordingly, the U-20 series also uses SI units. The following conversion table is provided for people who use the conventional kind of conductivity meter. Note that along with the change in unit systems, the measurement values and cell counts have also changed.

	Former units →	SI units
Measurement	0.1mS/cm →	0.01S/m
value	1mS/cm →	0.1S/m
	100mS/cm →	10S/m

3. Temperature coeffcient

In general, the conductivity of a solution varies largely with its temperature. The conductivity of a solution depends on the ionic conductivity, described earlier. As the temperature rises, conductivity becomes higher since the movement of the ions becomes more active. The temperature coefficient shows the change in % of conductivity per °C, with a certain temperature taken as the reference temperature. This is expressed in units of %/°C. The temperature coefficient assumes the premise that the conductivity of a sample changes linearly according to temperature. Strictly speaking, with actual samples, however, conductivity changes along a curve. Furthermore, the cuve varies with the type of sample. In the ranges of smaller temperature changes, however, samples are said to have the temperature coefficient of 2 %/°C (at reference tempreture 25°C) this holds for most samples, except in certain special cases.
(The temperature coefficients for various types of solutions are listed on the next page.)
The U-20 series uses an automatic temperature conversion function to calculate conductivity at 25°C at a temperature coefficient of 2 %/°C, based on the measured value of the temperature. Results are displayed on the readout.
The U-20 series's temperature conversion function is based on the following formula.

$$L_{25} = L_t / \{ 1 + K (t - 25) \}$$

L_{25} : Conductivity of solution converted to 25°C
(value displayed on U-20)
t : Temperature of solution at time of measurement (°C)
L_t : Conductivity of solution at t (°C)
K : Temperature coeffcient (%/°C)

Conductivity and temperature coefficient for various types of solutions

Conductivity and related temperature coefficients of representative substances (at 25°C) are shown in the table below.

Substance	Tempera -ture °C	Concentra -tion wt%	Conducti -vity S/m	Temperature coeffcient %/°C
NaOH	15	5	19.69	2.01
		10	31.24	2.17
		15	34.63	2.49
		20	32.70	2.99
KOH	15	25.2	54.03	2.09
		29.4	54.34	2.21
		33.6	52.21	2.36
		42	42.12	2.83
NH_3	15	0.1	0.0251	2.46
		1.6	0.0867	2.38
		4.01	0.1095	2.50
		8.03	0.1038	2.62
HCl	18	5	39.48	1.58
		10	63.2	1.56
		20	76.15	1.54
		30	66.20	1.54
H_2SO_4	18	5	20.85	1.21
		10	39.15	1.28
		20	65.27	1.45
		40	68.00	1.78
		50	54.05	1.93
		60	37.26	2.13
		100.14	1.87	0.30
HNO_3	18	6.2	31.23	1.47
		12.4	54.18	1.42
		31	78.19	1.39
		49.6	63.41	1.57
H_3PO_4	15	10	5.68	1.04
		20	11.29	1.14
		40	20.70	1.50
		45	20.87	1.61
		50	20.73	1.74
NaCl	18	5	6.72	2.17
		10	12.11	2.14
		15	16.42	2.12
		20	19.57	2.16
		25	21.5	2.27

Substance	Tempera -ture °C	Concentra -tion wt%	Conducti -vity S/m	Temperature coeffcient %/°C
Na_2SO_4	18	5	4.09	2.36
		10	6.87	2.49
		15	8.86	2.56
Na_2CO_3	18	5	4.56	2.52
		10	7.05	2.71
		15	8.36	2.94
KCl	18	5	6.90	2.01
		10	13.59	1.88
		15	20.20	1.79
		20	26.77	1.68
		21	28.10	1.66
KBr	15	5	4.65	2.06
		10	9.28	1.94
		20	19.07	1.77
KCN	15	3.25	5.07	2.07
		6.5	10.26	1.93
NH_4Cl	18	5	9.18	1.98
		10	17.76	1.86
		15	25.86	1.71
		20	33.65	1.61
		25	40.25	1.54
NH_4NO_3	15	5	5.90	2.03
		10	11.17	1.94
		30	28.41	1.68
		50	36.22	1.56
$CuSO_4$	18	2.5	10.90	2.13
		5	18.90	2.16
		10	32.00	2.18
		15	42.10	2.31
CH_3COOH	18	10	15.26	1.69
		15	16.19	1.74
		20	16.05	1.79
		30	14.01	1.86
		40	10.81	1.96
		60	4.56	2.06

● SAL conversion

The U-20 series is designed to measure salinity as well as the other parameters.
Note that the "salinity" referred to here is the salinity of sea water. There is a constant relation between conductivity and salinity at certain temperatures.
Therefore, if data on the conductivity and temperature are available, the corresponding salinity is known. In other words, the salinity measurement of the U-20 series is based on the principle of calculating the salt content, making use of the measured values of conductivity and temperature.
Note therefore, that measured results of all substances whose conductivity is detected are displayed as salinity. For example, the measured result is displayed as NaCl concentration, even if in fact the sample component is, for example, hydrochloric acid (HCl).

● TDS conversion

TDS is short for Total Dissolved Solids and means the total dissolved solid amount.
The conductivity of a solution is affected by the amount of salinity, minerals, and dissolved gases. That is, conductivity is an index that shows the total amount of all substances in the solution. Of these substances, TDS indicates only the amount of dissolved solids.
TDS can be used for a comparison of the state of substances composed of a single component such as NaCl. However, the use of TDS for the comparison of solutions of different types causes serious errors.
Conductivity and TDS are expressed by the following formulas:

Conductivity in SI units (S/m) ..... TDS(g/L) = L (S/m) × K × 10
TDS(g/L) = L (mS/m) × K ÷ 100
Conductivity in the old units (mS/cm) ..... TDS(g/L) = L (mS/cm) × K
K = TDS coefficient

Initial settings use the values listed in the table (☞ Page 72) that generally uses TDS coefficients.
For accurate TDS comparisons, find the TDS coefficient from measured conductivity values. Then set the value thus obtained and make measurements.

● σ_t conversion

Specific gravity of seawater

The density and specific gravity of seawater are equal numerically and generally are not distinguished strictly. Since seawater density ρ is between 1.000 and 1.031, 1 is subtracted from ρ and σ is obtained by multiplying the value by 1000.
The resultant value is used as the specific gravity of seawater.

$$\sigma = (\rho - 1) \times 1000$$

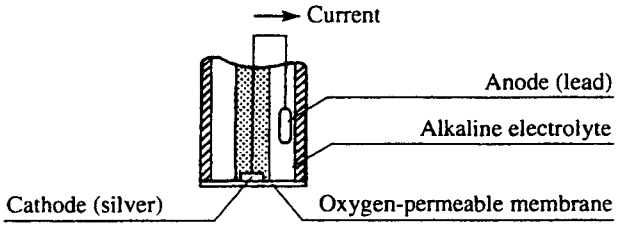
The density of seawater ρ is expressed by temperature, hydraulic pressure, and salinity functions. The density of seawater σ under the atmospheric pressure is expressed as σ_t. The density of seawater under the atmospheric pressure is determined by temperature and salinity.
The U-20 Series models make salinity measurement through temperature measurements and conductivity conversion and find σ_t through calculations.
In Japan σ_{15} at 15°C is called a standard specific gravity and widely used while in foreign countries σ_0 at 0°C is employed. σ_{15} and σ_0 are determined by the function of salinity.
In ocean surveys, in particular, these values σ_t, σ_{15}, and σ_0 are more widely used than conductivity and salinity and, in the U-20 Series models, newly added as measurement components.

● DO measurement

1. Principle of measurement

The "DO" referred to here means the concentration of oxygen dissolved in water. DO is essential to self-purification of river and sea and to water creatures such as fish. DO measurement is also essential to drainage and water quality control.

Fig. 3 shows the principle of measurement using a DO sensor.



(Fig. 3 Principle of DO sensor)

A noble metal (silver) is fitted closely to an oxygen-permeable membrane to make the cathode; a base metal (lead) is used as the anode. Both are immersed in an alkaline electrolyte with the anode-to-cathode external circuit closed. Oxygen diffusing through the oxygen-permeable membrane causes a reduction reaction at the cathode; this allows flow of current in the external circuit:

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

At the anode, oxidation reaction occur as follows:

$$2Pb \rightarrow 2Pb2^+ + 4e^-$$

The current is proportional to the quantity of oxygen diffusing through the oxygen-permeable membrane. Accordingly, measurement of the current makes the DO in a sample known.

The DO measuring method based on this principle is called the membrane-electrode method. This method allows convenient measurement of DO, especially when compared with chemical-analysis method, which needs complicated pre-treatment to eliminate the effects of oxidizing or reducing substances.

2. DO correction for salinity

When a solution and air are in contact and in complete equilibrium (saturated), DO: C [mg/L] in the solution, and the oxygen partial-pressure: Ps [MPa] in air are in the following relation:

$$C = Ps/H$$

H [MPa/ (mg/L)] is referred to as Henry's constant, which depends on the composition of the solution. In general, C becomes smaller as the salinity in the solution increases, since H becomes larger.

A DO sensor is intended to detect Ps in the above expression. Therefore, the DO measurement would be in error if the DO sensor were immersed either in air-saturated pure water or in solution with salt. To settle this problem, it is necessary to correct the DO reading based on the salinity of the sample using salinity correction.

Conventional DO meters make this salinity correction by inputting a known salinity value. This poses no problems if the salinity of the sample is known. In general, however, the salinity of the sample is usually not known, and the method is not practical even if the DO meters are equipped with the salinity correction function.

The U-20 series is capable of measuring the salinity of a sample and automatically correcting the using this function.

3. Features of the U-20 series DO sensors

In conventional DO measurements, it was necessary to keep the velocity of the flow constant because the velocity of flow led to fluctuation in indicated values. In our U-20 Series models, improvements in sensors have made it possible to make measurements with stable indications and with little influence of the velocity of flow.

● Turbidity (TURB) measurement

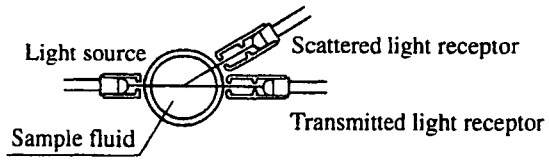
1. Principle of measurement

From among several types of turbidity-measuring methods available, the U-20 series uses the light-transmission-scattering method, shown in Fig. 4.

Irradiation of a beam of light onto a sample brings about separation of the beam into (1) the light transmitted through the solution and (2) the light scattered by turbidity components in the sample. In the light-transmission-scattering method, the intensity of both transmitted light and the scattered light are measured using separate receptors, and the turbidity is obtained based on the ratio of the two.

With the U-20 series, the light source is a pulse-lighting infrared-emission diode. The scattered light is measured at a point 60° offset from the light source. This light-absorption-scattering method has several advantages, including the fact that (1) the actual color of the sample fluid has little effect on the measurement of turbidity, (2) fluctuations in light quantity from the light source are easily compensated for, and (3) it allow the U-20 series to be operated with relatively low-power consumption.

The turbidity value differs with the structure of the cell so changes with the instrument.



(Fig. 4 Principle of the light-transmission-scattering method)

2. Standard solution

U-20 series can perform calibration using formazin (NTU) or kaolin standard solutions as a turbidity standard solution. However, units for the solution used for calibration should be displayed in measurements. Do not use more than 400 mg/L of kaolin standard solution because it increases precipitation speed, resulting in measurement error.

● DEP measurement

1. Depth (DEP) measurement

For the U-22 and U-23 models, depth measurement can be made through use of a pressure gauge. The principle of the depth measurement uses the relation between depth and pressure.

Although the measurement with the depth sensor is affected by atmospheric pressure, the depth sensor, however, makes zero-point adjustments through the automatic calibration before measurements.

2. Influence of temperature and calibration

The depth sensor depends greatly on temperature. For a wide difference between the temperature at which the sensor has been automatically calibrated and the temperature of the measurement sample, the sensor can make depth measurements with a higher accuracy by the following method:

Immerse the depth sensor of the sensor probe into the sample.

Keep the sensor immersed in the sample for approximately 30 minutes until the temperatures of the sensor and the sample are the same.

Then make the zero calibration of the sensor manually. (☞ Page 57)

● Measuring mV (oxidation-reduction potential (ORP))

ORP principles

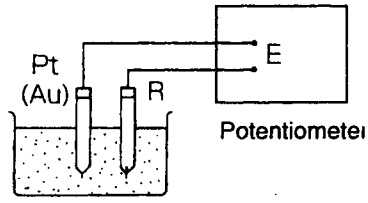
ORP (or "redox potential") is an abbreviation for oxidation-reduction potential. ORP is the energy level (potential) determined according to the state of equilibrium between the oxidants (M^{Z+}) and reductants $M^{(Z-N)+}$) that coexist within a solution.

$M^{z+} + ne^- \Leftrightarrow M^{(z-n)+}$.....①

If only ① exists within a solution, a metal electrode (platinum, gold, etc.) and a reference electrode are inserted into the solution, forming the ORP measuring system shown in Fig. 5. Measuring the potential (ORP) that exists between the two electrodes enables the potential to generally be expressed by the following equation.

$$E = E_0 - \frac{RT}{nF} \ln \frac{a_M^{(z-n)+}}{a_M^{z+}} \quad \text{..... ②}$$

E: Electric potential E_0 : Constant R: Gas constant T: Absolute temperature
n: Electron count F : Faraday constant a : Activity



(Fig. 5 Measuring mV)

For example, for a solution in which trivalent iron ions coexist with bivalent iron ions, equations ① and ② would be as follows.

$Fe^{3+} + e^- \Leftrightarrow Fe^{2+}$.....①

$$E = E_0 - \frac{RT}{F} \ln \frac{a_{Fe^{2+}}}{a_{Fe^{3+}}} \quad \text{.....②}$$

When only one type of state of equilibrium 1 exists in the solution, the ORP of the solution can be determined uniquely by equation 2. What is important here is that ORP is determined by the ratio of activity between the oxidant (Fe^{3+}) and the reductant (Fe^{2+}) (using the equation $a_{Fe}{}^{2+}/a_{Fe}{}^{3+}$). Actually, however many kinds of states of equilibrium exist simultaneously between various kinds of ions, in most solutions. This means that under actual circumstances, ORP cannot be expressed using the simple equation shown above and that the physical and chemical significance with respect to the solution is not very clear.

In this respect, the value of ORP must be understood to be only one indicator of the property of a solution. The measurement of ORP is widely used, however, as an important index in the analysis of solutions (potentiametric titration) and in the disposal and treatment of solutions.

Recently, there have appeared various claims regarding this matter, such as that a high degree of ORP is effective in sterilization or that drinking water that has a low ORP reduces the chance of illness by reacting with the activated oxygen in the cells of the body. ORP is used as an index for alkaline drinking water.

● Ion measurement

1. Ion concentration measurement

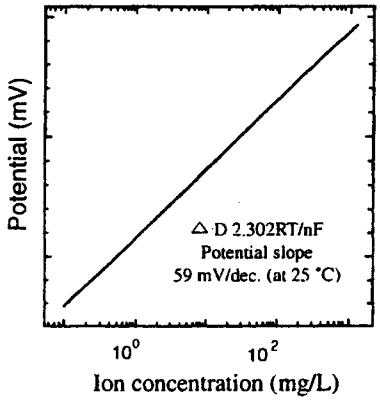
When certain ions exist within the solution that is to be measured, the responsive ion sensor membrane generates an electric potential corresponding to the concentration of the ions. The potential that is generated is measured by the ion meter as potential, using the reference electrode as the standard. With ion sensors, the measured potential and the logarithm of the ion activity within the solution being measured are generally proportional to each other and are expressed in the following way.

$$E = Eo + (2.303\ RT/nF)\ log\ [\ \gamma\ C]$$

E : Measured electric potential (V)
Eo : Standard potential (V), determined according to the system. This includes the standard potential of the reference electrode and the liquid junction potential.
F : Faraday constant (96,485 $Cmol^{-1}$)
R : General gas constant (8.314 $JK^{-1}\ mol^{-1}$)
T : Absolute temperature (K)
n : Ion valency
γ : Activity coefficient
C : Ion concentration (mol/L)

The above formula is called "Nernst's equation" and is the basis for measuring ion concentration using an ion sensor. The part of the above Nernst's equation that reads "2.303 RT/nF" is the change in potential generated when the ion concentration changes by a factor of 10.
This change in potential is called the "potential slope," "incline," "slope," or "Nernst's factor." If the above equation is adhered to when calibrating with standard solution and determining the value of the potential slope and E_0, finding the potential E of the ion sensor inside the solution being measured will enable the ion concentration to be determined. When actual measurement is performed, the ion sensor measures the ion concentration, so a linear relationship forms between the value of the ion concentration and the electrode potential, if the concentration is plotted on a logarithmic axis, as shown in Fig.6. Conducting quantitative analysis using an ion sensor requires either an ion meter that has an logarithm calculation function or the creation of a calibration curve using semi-logarithmic graph paper.

Calibration curve for univalent positive ion electrode



(Fig. 6 Relationship between ion concentration and electric potential)

2. Standard solution

Finding the ion concentration of the solution being measured requires prior calibration of the ion meter using a prepared standard solution with a known ion concentration. The number of times the meter is to be calibrated depends on the accuracy desired. Calibration is usually performed once a day or prior to making measurements. Calibrating the meter when the standard solution has been mixed using a stirrer or other utensil will improve the electrode responsiveness and measurement stability.

* Basically, at least two standard solutions of different concentrations should be used to calibrate this meter. If the approximate ion concentration of the liquid to be measured is known, standard solutions having lower and higher concentrations than that liquid should be used for calibration. In such cases, the standard solution with the lower ion concentration should have 1/10 the concentration of the standard solution with the higher concentration.
* If the approximate ion concentration of the liquid to be measured is unknown, choose low and high-concentration standard solutions with a larger differential than the 1/10 used in the above example. However, be sure not to exceed the limits of the linear ion sensor detection capabilities.

3. Notes on use of ion sensors

<Measuring range>

Use measured values in the ion concentration range for individual ion sensors.

<pH range>

There is a pH range suitable for measurements for each ion sensor. Make ion measurements in the pH range.

<Hindering ion>

Some ion sensors respond to other ions than ions to be measured. Smaller permissible coexistence limits in the table below cause more serious errors. For ion sensors that cannot withstand hindering ions, the responsive membrane will be broken. Handle ion sensors with care.

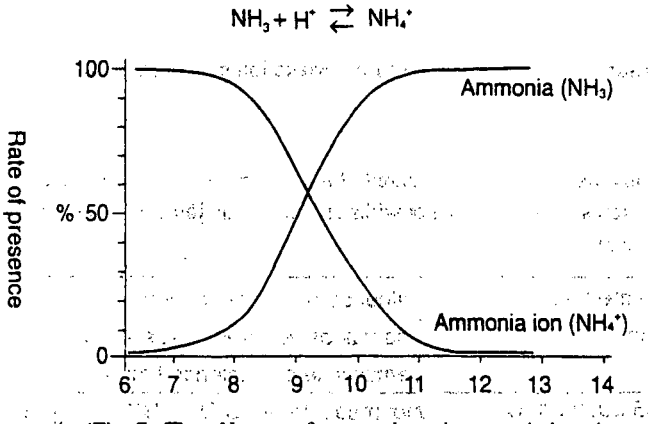
Model Ion type	Sensor type (Quantity)	① Measurement range ② pH range	Influence of hindering ions The values in parentheses show permissible coexistence limits.	Valency
6522 Cl^-	#7660 (1 piece)	① 0.4 to 35,000mg/L Cl^- (1 to 10^{-5}mol/L Cl^-) ② pH3 to 11 (350mg/L Cl^-)	Not measurable: $S_2O_3^{2-}$, S^{2-}, I^-, Ag^+, Hg^{2+} Br^- (0.03), MnO_4^- (0.1), SCN^- (0.3) (In the10^{-3} mol/L Cl^-)	−1
6530 F^-	#7661 (1 piece)	① 0.02 to 19,000mg/L F^- (1 to 10^{-6}mol/L F^-) ② pH4 to 10 (20mg/L F^-)	OH^- (10) (In the measurement range)	−1
6531 NO_3^-	#7681 (1 piece)	① 0.62 to 62,000mg/L NO_3^- (1 to 10^{-6}mol/L NO_3^-) ② pH3 to 7 (62mg/L NO_3^-)	ClO_4^- (0.02), I^- (0.1), NO_2^- (3), Cl^- (40) F^- (200), CH_3COO^- (300) (In the10^{-3} mol/L NO_3^-)	−1
6532 K^+	#7682 (1 piece)	① 0.04 to 39,000mg/L K^+ (1 to 10^{-6}mol/L K^+) ② pH5 to 11 (3.9mg/L K^+)	Rb^+ (0.4), Cs^+ (3), NH_4^+ (70) (In the10^{-4} mol/L K^+)	+1
6533 Ca^{2+}	#7683 (1 piece)	① 0.4 to 40,080mg/L Ca^{2+} (1 to 10^{-5}mol/L Ca^{2+}) ② pH5 to 11 (3.9mg/L Ca^{2+})	Fe^{3+} (0.1), Fe^{2+}, Zn^{2+} (1), Sr^{2+} (50), Ni^{2+}, Cu^{2+} (70), Co^{2+} (350), Mn^{2+} (500) (In the10^{-4} mol/L Ca^{2+})	+2
5012 NH_3	—	① 0.1 to 1,000mg/NH_3 (0.1 to 10^{-5}mol/L NH_3) ② Some exist as NH_3 at pH 8 or more. All ammonia components exist as NH_3 at pH 12 or more.	Substance that emits acid and basic gases (Volatile amine)	−1

Important

- Because of the above properties, the NO_3^- ion sensors cannot be used in seawater.

4. Properties of the ammonia ion sensor

The optional ammonia sensor for the U-23 model measures ammonia gas (NH_3).
Ammonia gas (NH_3), which is a component in water, and ammonia ion NH_4^+ exist differently depending on pH. (Fig. 7)



(Fig. 7 The pH rates of ammonia and ammonia ions in water.)

Before making measurements of only the ammonia (NH_3) in the sample, therefore, it is necessary to only immerse the ion sensor into the sample. Before making measurements of all ammonia components, it is necessary to change ammonia ion (NH_4^+) into ammonia gas (NH_3) by pouring the sample into the calibration beaker and adding approximately 0.3 g of sodium hydride.